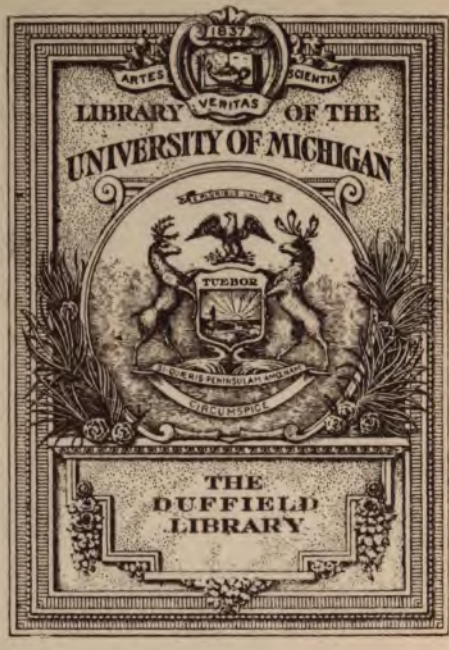

SUGGESTIONS

RELATIVE TO THE

PHILOSOPHY OF GEOLOGY,

AS DEDUCED FROM THE FACTS AND TO THE CONSISTENCY OF BOTH

THE FACTS AND THEORY OF THIS SCIENCE WITH

SACRED HISTORY.

BY PROF. B. SILLIMAN.

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APPENDIX

TO THE

THIRD AMERICAN FROM THE FIFTH ENGLISH EDITION OF

BAKEWELL'S GEOLOGY.

SUGGESTIONS RELATIVE TO THE

PHILOSOPHY OF GEOLOGY

AS DEDUCED FROM THE FACTS AND TO THE CONSISTENCY OF BOTH THE FACTS AND THEORY OF THIS SCIENCE WITH

SACRED HISTORY.

INTRODUCTORY REMARKS.

My acquaintance with the Geology of Mr. Bakewell commenced with the first edition, published in 1815.

Being strongly impressed by its perspicuity, attractiveness, and sound philosophy, I made it the companion of my lectures on this science, and in 1829, an American edition, from the third English, was published at New Haven, under my supervision, and with the author's privity and approbation. The work met so favorable a reception in this country, that a second American edition, from the author's fourth, also with his approval, was edited by me in 1833, and thus it became generally known in the United States, as a book of standard authority.

It appears, that the republications in this country produced so favorable an influence at home, that, from being less generally known there, than its great merits deserved, this work soon made its way into several of the first British universities; and we infer, from the appearance of a fifth edition, that it continues to main-

tain its ground with other excellent treatises on geology, which have appeared long since this was first published.*

It is in accordance with Mr. Bakewell's wishes, that I now pass a third American edition to my countrymen, not doubting that I am doing to them and to all our students of geology an acceptable service.

In relation to the present edition, I have revised the discourses which were appended to the two former American editions of 1829 and 1833. They have been greatly condensed, and to some extent written anew, with the intention of bringing them up to the present state of the science.

The outline of my lectures, annexed to the first American edition of 1829, does not present a correct view of the courses which I now give. Fifteen years have elapsed since that outline was first sketched, and ten since it was published. Within those periods geology has made great advances, particularly in the proofs of igneous action, in all ages, ancient and modern; and perhaps my own admissions of its agency were not commensurate with the proofs that existed in 1833. The powerful direction early given to my mind, towards the Wernerian theory, by the captivating eloquence of the late Dr. John Murray of Edinburgh, whose lectures on geology as well as chemistry I attended, was not, at that time, fully appreciated by myself.

I was also a deeply interested listener to the lectures of Dr. Hope,† based on the Huttonian theory, and I was a careful student of Playfair's splendid illustrations of that theory; while Playfair himself, with many other eminent men of that school of geology, as well as of its rival,‡ was then in full vigor and activity at Edinburgh. It was delightful to listen to their eloquent statements and acute reasonings. In this way I heard both sides of the question fully vindicated, while, from my youth and inexperience, I endeavored to sustain a neutral position, and reserved the liberty to decide ultimately, with an unbiased mind. Still I was, to a degree, incredulous in regard to the fundamental postulates of

* We are informed that it has been translated and published in Germany.

† The distinguished Professor of Chemistry, &c. in the University of Edinb.

‡ Professor Jameson, then recently returned from Germany, where he had studied under Werner, had not at that time entered on his public duties.

the Huttonian geologists, and could not perceive that they made out their case, as to the extent and energy of internal fire. The powerful arguments in favor of great igneous action, contained in Mr. Bakewell's Geology, were supported by Dr. Daubeny's fine Treatise on Volcanoes, and this by the full and exact work of Mr. Scrope on the same subject, with particular reference to the extinct volcanoes of France, illustrated also by an ample atlas of volcanic regions. The more recent exhibition of proofs by Mr. Lyell, as to the extent, persistence, and energy of igneous action; the satisfactory evidence accumulating every year respecting the increasing internal heat as we descend into the earth; the decisive influence of galvanic power in mineral veins, as ascertained by Mr. Fox, its efficiency in producing mineral crystallization and its power even in rousing into life the long latent eggs and germs of insects, as established by Mr. Crosse—with the splendid proofs which our galvanic and electro-magnetic machines now afford of an igneous energy inherent in the earth—an energy which knows no limits —attended also by magnetic and decomposing power, equivalent to all which geology demands; these and many other considerations that might be stated, have removed my doubts, and I have been for a series of years in a condition to do full justice to the internal agency of fire, as my various classes in the university and elsewhere can attest.

It is of little importance to occupy the reader's attention, even for a moment, with my own personal views and opinions, nor would I have ventured to do so, were it not of some importance that the science may not suffer by any apparent, although not real, caprice of opinion in those who teach it to others. I have therefore thought it but honest to make this frank declaration, my *amende honorable*, of the change in my views, and of the grounds of it; and perhaps it may not be entirely without utility, as an exhibition of the effect of progressive development and accumulation of evidence upon one mind, inasmuch as other minds may, by similar means, be led to the same result. If, however, I still sustain the claims of water and of all things which, by the aid of heat and pressure, water is able to dissolve—to more efficiency than is now generally conceded to them—it is I trust not so much because I am still tenacious of early impressions, as because

the state of experimental science, both mechanical and chemical, fully bears us out, in attributing powerful solvent properties to water, aided especially by heat and pressure and many active chemical agents.

The remarks on the consistency of the facts and theory of geology with the scripture history, although superfluous with respect to learned geologists, and even learned theologians, who have studied and understood both sides of the question, appear to me to be still demanded by the state of moral feeling, and by the imperfect comprehension of geological truths on the part of the majority even of our educated people. I have therefore retained a condensed view of this question, which was discussed in connexion with the edition of 1833.

I. General Object of Geology.—The object of this science is to ascertain the structure of the earth; the nature of its mineral aggregates; their disposition and arrangement, forming rocks and mountains; the relative position and nature of the rocks themselves, with their included minerals and organic remains; the useful substances which they contain; the natural associations of these with other substances; the proximate causes, which have given the mineral masses their present form and position; and those, which, operating upon them still, are causing them to undergo alterations, more or less considerable, and are producing changes, which will ultimately give them new forms of existence.

II. Positive and Speculative Geology.—It is obvious, therefore, that geology is erected upon observation, and not upon mere speculation; yet, speculation is with propriety admitted, as an important means of advancing the science; but it is of no value if not founded upon facts, and they must never be contradicted by it.

Positive is therefore the parent of speculative geology, and it proceeds, like the other natural sciences, upon a careful examination of particulars; from particular it ascends to general conclusions, and upon these builds legitimate theory. Thus, there is a clear distinction between geological theory and geological hypothesis. The former draws conclusions directly from facts, and follows strictly the inductive course. It has therefore the same

foundation, as general physics; and its conclusions often approximate to demonstration. The latter also appeals to facts, but in a manner less conclusive, and it sometimes makes suppositions of facts, not actually proved to exist.

III. Former and present State of Geological Knowledge in this Country.—Before the American revolution, geology as a science, had no existence in this country, and indeed there was hardly any thing in Europe that deserved the name.

In Mr. Lyell's Principles of Geology, there is an interesting historical sketch of the rise and progress of geological research and opinion, from the ages of Grecian, Arabian, and Roman philosophy to that of the revival of letters in Europe; and from that period, through several centuries to our own time. Vigorous minds have indeed appeared in various and remote periods, which have formed just conceptions of some parts of geology, but it could not be said to have taken the form of a science until the Wernerian and Huttonian schools began their friendly conflicts, about 60 or 70 years ago.

In this country, considerable attention was early bestowed upon the research for metals and other valuable minerals, as is evinced by numerous excavations in our hills and mountains, whose date is generally in the first half of the late century. Several of the men are still living who led the way in introducing scientific geology among us. William Maclure* was the man who, from extensive personal examination, made the first geological sketch of the United States, after having visited geologically, most of the countries of Europe; he has also given us much interesting geological information respecting the West Indies, Spain, and other countries. He and others, his juniors in years and in the date of their knowledge, can well remember, when the names of the most common minerals and rocks were scarcely known in the United States. Now, there are geological cabinets and schools in many places, and many geological surveys have been made, or are in progress, under public authority. We have numerous good reports on states and territories, and many valuable

* Who now, at an advanced age, resides in the city of Mexico—a country which he finds congenial to his health.

memoirs on particular districts; they are to be found also in scientific journals, in books of travels, especially of the exploring expeditions sent out by the American government; in the transactions of learned societies; in detached publications, and sometimes even in the newspapers. These materials are of great value; but much more must be done before they will be sufficiently copious to enable some master spirit to reduce the whole subject to order, and thus to give a full and digested account of American geology. Foreign geologists will do us the justice to remember, that our field is vast, while our laborers, although every year increasing in number, are still comparatively few, and they are, generally, men occupied by other pursuits; this country is rarely explored by those whom fortune leaves at ease to follow a favorite object. The learned leisure of Europe, and especially of England, is here almost unknown, and our most efficient cultivators of science are also laborers in other fields. But the habit of making efforts by systematic industry, is often an equivalent for leisure. Many of our geologists labor with zeal and effect, and in the scientific corps, now surveying several of our states, we have men who are able to maintain their standing with those of any country.

IV. Limits of our Knowledge of the Earth.—It is only the *crust*, the superficial part of our earth, that we can examine; a few miles or leagues in depth of its outer rind. We no longer attempt, by a brilliant excursion of the imagination, to account for its present form; poetry and fiction have ceased to perform the work of philosophy; those obsolete hypotheses, falsely called theories—many of them adorned by the eloquence of powerful minds—which substituted waking dreams for the patient examination of facts, are no longer regarded, except as monuments of the restless activity of the human mind; which is inclined to repose on almost any conjecture, however visionary, rather than to confess its weakness and ignorance.*

In Europe, and we are now happy to say in America also, a great number of highly qualified men are occupied in geolo-

* The geological student may find a spirited outline of the most prominent geological hypotheses in Cuvier's Introduction to Geology; they may be read as a matter of amusement; but it will be easily perceived, that they bear no closer analogy to modern geology, than the visions of Alchemy sustain to modern chemistry.

gical researches; collectively they bring to the investigation, all requisite science and the habit of careful observation and induction, with the industry and patience, which are demanded. The progress made in these inquiries, even since the commencement of this century, is wonderful. Districts, provinces, and countries are surveyed; and this kind of research, favored by the propensity for travelling, to which it affords both a strong incitement and a high gratification and reward, will, doubtless, continue to be extended, until there shall be no countries unexplored, except those from which the *scientific* traveller is debarred, by insuperable moral or physical impediments.

Geology takes rank among the physical sciences, and is worthy of the attention of the greatest minds.

In grandeur, it falls indeed short of astronomy; and what physical science does not; since, astronomy presents to our optics, or to our intellectual vision, the "great frame work" of the universe; we pass from the view of our own planet to the entire planetary system, of which our earth is a member; and from this system, to other and similar systems; and to the immense systems of suns innumerable, with their attendant worlds, arranged and connected, in perfect harmony; performing all their revolutions without interference, or irregularity, and illustrating the power and wisdom and sustaining energy, of the omnipotent Creator and Governor. Still the structure of a single planet is a subject of great interest and grandeur; especially as we may reason from it *analogically*, respecting the structure of other planets.

V. Modes of Investigation and Sources of our Knowledge. —Our direct penetration into the earth, by mines, the deepest excavations of art, has scarcely exceeded three thousand feet—a little more than half a mile, not $\frac{1}{2000}$ part of the earth's diameter or $\frac{1}{4000}$ part of its radius.

It might therefore at first view, seem that we can attain only a very slight knowledge of the internal structure of the planet, and that it would be idle to attempt to speculate respecting that of which we can see so little. Still, we are able to reason correctly on this subject, for we have many sources of information and ample means of perusing the internal structure of our globe.

1. *The obliquity of the Strata.*—The strata or natural beds of rocks are found in all positions, from the perfectly vertical, to the perfectly horizontal. Were they all horizontal, it is obvious, that the edges could come into view, only on the sides of mountains, in the banks of rivers, on promontories, or in artificial excavations; and that, in a tolerably level country, we might travel over many leagues, and see very little change in the rock formations.

But if the strata are inclined to the horizon, then, their edges must come into view, unless the rocks are concealed by the soil or by ruins. Thus the strata, that in a given situation are many miles below the surface, may emerge, and *crop out*, in some other place. Were the soil and diluvium removed, from a series of inclined strata, then, their edges would appear, and we could have no reasonable doubt that we should see an adequate representation of the subterranean geography, as far as those strata extended downwards; perhaps for many leagues—or possibly for hundreds of miles beneath the surface. The same instruction is obtained from vertical strata, and indeed from those in all positions, except the perfectly flat; and even then, we are not without means of information.

2. *Horizontality—Density of the Earth.*—Strictly, a horizontal position is parallel to the general curve of the earth's surface, considered without reference to the hills and mountains. Were this horizontal position strictly preserved, and were there no perforations and ruptures of the strata, by artificial or natural causes, we should, except in the sides of hills and mountains, see only the upper stratum of rock, and our knowledge of the geology of the region in question, would be confined, very nearly, to the visible material beneath our feet. A horizontal stratum may overlie parallel strata, descending so deep as to come out obliquely at points distant from the position of the observer, and thus to exhibit inclined or even vertical strata cutting off a segment of the globe.

In common with the pressure of superincumbent masses, it may be proper to mention the density of the earth. By the conclusions of the British and French philosophers, the mean specific gravity of the earth is at least twice that of the most common rocks and stones.

This important conclusion implies nothing more than a highly condensed state in the materials in the interior of the earth; still it does not prove a prevalence of metals, in the sense in which they are generally known to mankind. It is, however in full proof, that metals, such as are known only to chemists, form the basis of the rocks, and in their oxidized and mineralized condition, they may, from pressure or from other causes, acquire a high specific gravity. This is illustrated by carbon as it exists in diamond, in which it is three or four times as heavy as in the bitumens, and six or eight times as heavy as in charcoal; alumina, in sapphire, sustains a similar relation to the alumina of clays, and so does pulverulent carbonate of magnesia to that earth in boracite or in chrysoprase; or silica in swimming fluid *(quartz nectique)* to the same substance in rock crystal. Thus the specific gravity of the entire mass of the earth compared with that of the surface may present no contradiction or inconsistency.

3. *Mines and Wells.*—The excavations in mining are the most profound that have been made by art. The deepest mine in the world, that of Truttenberg in Bohemia, penetrates three thousand feet into the earth. In all mines, the strata being perforated and broken, we obtain the most satisfactory information, as to the nature and arrangement of the rocks. Few of the mines of England are, in perpendicular descent, deeper than a quarter of a mile, (Dolgoath in Cornwall,) and none in the United States exceed four or five hundred feet, (Richmond coal mines, and those of Pennsylvania.)

The evidence afforded by wells is of the same nature. The depth attained rarely equals one hundred feet, but in some instances it extends to two hundred, three hundred, four hundred, &c. as at Carisbrooke Castle in the Isle of Wight, on the plain or valley of London, &c. (Conybeare and Philips.)

4. *Boring for Salt Water, Salt Mines, Coal, &c.*—This affords similar, though less distinct evidence; because the materials are brought up, in the state of powder, or at least of small fragments, and a very imperfect idea is thus obtained of their original appearance; sufficient however to enable us to decide on their nature. These operations are often carried on to the depth of several hundred feet—sometimes 600 to 800 feet or more.

5. *Roads, Canals, and Tunnels.*—Roads and canals are sometimes cut through diluvium, as on the Welland Canal, in Upper Canada, where the cut is in some places, more than fifty feet deep, in a stiff tenacious clay; and even through solid rocks, as at Lockport on the Erie Canal, where for two miles or more, a very solid, subcrystalline limestone has been excavated by blasting, in many places to the depth of thirty feet, disclosing not only the nature of the rock, but many beautiful imbedded minerals and fossils—strontian, gypsum, calc spar, corals, crinoidea, &c.

Tunnels are less numerous, but every one has heard of that of the Duke of Bridgewater, between Liverpool and Manchester, and of the Thames Tunnel, below London, intended to serve as a substitute for a bridge. That under Standedge, between Huddersfield and Manchester, extends upward of three miles, and is two hundred and twenty yards below the surface.

It appears that they were not unknown to the ancients. From the Stadium near Athens, situated in a natural defile, the vanquished charioteers retired through a tunnel which perforated a neighboring hill, and thus those who had failed of victory were screened from the sneers and insults of the populace.* Tunnels are becoming common in this country, as between Philadelphia and Pittsburgh; at Harlem, near New York; at Norwich, Connecticut, and in various other places. These and all other excavations into the earth add to our means of geological information.

6. *Rivers and other Water Courses.*—Brooks gently transport gravel and sand, and rivers rush through mountain defiles, as if they had burst the rocky barriers, transporting not only sand and gravel and pebbles, but at times large bowlder stones, bearing them along and vexing them with incessant friction, till their angles are rounded or obliterated. The rivers have sometimes flowed at a higher level, or their waters are the remnants of lakes whose barriers time has broken or worn away; and water-worn ledges are often found at elevations higher than where the floods can now flow. This is seen two or three miles below Bellows' Falls, on Connecticut River, where the primitive rocks

* Dr. Howe's personal communications, Aug. 11, 1828.

shew the same water-rounded angles, furrowed lines, and even pot holes, formed and polished by ceaseless attrition, as are seen at the Falls themselves, whose torrents are now incessantly wearing the rocks. Similar facts are observable at the head of Lake George, fifty feet and more above the lake, in ledges of transition limestone, over which no water now flows. The same appearances are seen at the great falls of the Potomac; where, for a long distance, and at a considerable elevation above the present bed of the river, the angles are rounded and smoothed, and there are numerous holes in the rock, either shallow and irregular, or deep and cylindrical, like those of cataracts, and certainly produced by the same causes, the wearing of water, aided by whirling stones.*

The passage of the Shenandoah through the Blue Ridge—of the Connecticut at Middletown, through the Haddam hills, and of the rivers in the Rocky mountains through their defiles; these are a few among innumerable examples of this kind. The rivers have rarely burst their barriers; in general, they have merely uncovered the rocks so that their characters can be observed; they have not generally formed their own beds, but have deepened and altered their channels. The Genesee and Niagara rivers, whose banks are often precipitous and several hundred feet high, give sections of the strata wonderfully distinct and beautiful. Thus the wearing power of water contributes to the mass of geological evidence.

7. *Valleys and Defiles, Banks, Precipices, Cliffs and Promontories.*—In every mountainous country not covered with soil and ruins, these natural sections being often deep, abrupt, and of great extent, expose the stratification on the sides of the hills and mountains, and thus the structure is revealed. As a large part of the earth is mountainous, provision is thus made, on a great scale, for judging of the interior of the planet. The shores of the seas and of the great lakes, and all elevated countries, abound with such exhibitions. Many of them are indeed inaccessible except in boats, but however viewed, they exhibit the stratification and structure more or less distinctly.

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* American Journal, Vol. iv, p. 44.

8. *Landslips, Slides and Avulsions.*—The peaceful dweller in the beautiful Isle of Wight, in the English channel, not unfrequently sees the high chalky cliffs of that coast, that have been undermined by the sea, totter to their fall, till they come thundering down in piles of ruins; and even at some distance inland, away from the sea, they occasionally slide or slip from their seats, overwhelming the plains below.

The Alpine mountaineers witness still more stupendous catastrophes. Large portions of mountains are precipitated with frightful devastation upon the valleys and plains, filling the bosom of lakes, spreading desolation far and wide, and burying villages in the wreck, or sweeping them away by the sudden rush of the waters.

The mountains of Vermont and of New Hampshire, have been the scenes of similar catastrophes, and the Notch in the White Mountains of the latter State, will long record the desolations of 1826. The Notch is a grand defile in these mountains, five or six miles in length, formed by a double barrier, rising abruptly half a mile or more in perpendicular altitude, from both sides of the wild roaring river Saco, which washes the feet of the barriers. A single carriage can hardly pass between the stream and the mountains, and the road is in some places cut into the mountain itself. The ridges are capped by castellated turrets of rocks, rising in high zigzag turns, which thus imprison the observer in a vast, gloomy gulf.

The sides are deeply scarred by many floods, and especially by the memorable deluge of the night of August 28th, 1826, which destroyed, in a moment, an entire family of nine, and left not one to tell their story. The Willeys occupied a lonely house in the wildest part of the Notch, at the foot of the mountains; it was a resting place for travellers. For two seasons before, the mountains had been very dry, and on the morning of August 28th, it commenced raining very hard, with strong tempestuous wind; the storm lasted through that day and the succeeding night, and when it ceased, the road was found obstructed by innumerable avalanches of mountain ruins, which rendered it impossible to pass, except on foot. They were rather slides than ruptures of the rock: they began at or near the mountain top, and bore down

the precipitous sides, the shrubs, the forests, the soil, stones and rocks; and of the latter, many of great size.

One of the torrents descended behind the house, and dividing into two branches, bore away the unhappy family, who, in the deep darkness and wild fury of the tempest, issued from their dwelling only to be overwhelmed by the torrent, which desolated the mountain gorge for a distance of two miles,* filling it with almost continued masses of ruins, borne down by the deluge from both sides of the defile.

Such are some of the disclosures made by violent torrents, by slides and revulsions.

9. *Revelations by Fire.*—Volcanic eruptions throw up into daylight the foundations of the fathomless deep below, in the form of ejected masses, or in rivers of ignited and fluid rocks, which congeal on the surface of the ground, either inflated, like the scoriæ of furnaces, or in solid forms, with no visible impress of heat. They often contain very perfect and beautiful minerals, conceived in the volcano, or dislodged from still earlier beds, from a more profound igneous abyss, from which they are urged along by the irresistible current that often ruptures the crust of the earth, and covers it with a fiery deluge. In addition to the products of actual volcanoes, we observe the ignigenous rocks, crystallized or deposited from fusion, both in the earliest and in many of the more modern epochs, injected among, and cutting across strata of almost all descriptions and ages, and thus assimilated to known products of internal fire; these proper rocky masses, the granites, the sienites, the porphyries, the serpentines and the traps, give authentic information of the unapproachable gulf of fire whence they were projected.

10. *By Cold and Hot Springs and Gases.*—The internal waters that gush cool from the fountains on land or under the

* During a visit to this place in May, 1828, two years after the event, there was still visible a vast rampart of earth, stones, rocks, and trees piled up behind the house, at the place where the torrent divided, and left the building unharmed, although it swept away the barn and cattle, sparing, however, a flock of sheep which lay near by upon a green sward. I was there again in August, 1837, nine years after my former visit, and found the ruins near the house so covered with earth, and even grass, that they were almost concealed from the eye, thus serving as a geological chronometer.

sea, or those that spout in boiling geysers from the deep caverns where their imprisoned vapors accumulate explosive force; all these bring to the surface the materials of the interior, and conspire with tornadoes of gas bursting from volcanoes and other vents, to reveal the deep secrets of the earth.

VI. Fruits or Results of the Observations made on the Structure of the Crust of the Earth.—*The earth is not*, as ignorant persons usually suppose, *a mere rude and unarranged heap of rocks* and minerals, grouped together without order or plan, and incapable of being rationally investigated.

Order, so conspicuous in the mechanism of our planetary world and the stellary universe; in the equilibrium of projection and gravitation; of cohesion and expansion and chemical affinity, and in the structure and exact economy of animals and vegetables, pervades, indeed, all the works of creation; nor is it less capable of demonstration, although the proof is less obvious, in this unconscious earth, than in the other departments of God's universal dominion.

VII. Beauty and Interest of Geology as a Science.—In relation to the beauty and interest of geology, we may remark, that no field of science presents more gratifying, astonishing, and (but for the evidence) incredible results. Man has been but a few thousand years a tenant of this world; nothing which we discover in the structure of the earth, would lead us to infer that he existed at a period more remote than that assigned to him by the Scriptures. Had he been cotemporary with the animals and plants of early geological periods, we should have found his remains, and his works, entombed along with them.

Opinion of Berkeley.—This argument forcibly impressed the mind of Bishop Berkeley, a century ago, and the following beautiful passage is cited from him by Mr. Lyell.* "To any one who considers that on digging into the earth, such quantities of shells, and in some places, bones and horns of animals, are found sound and entire, after having lain there, in all probability, some thousands of years; it would seem probable that gems, medals, and implements in metal or stone, might have lasted entire, bu-

* Principles, 5th edition, Vol. III, p. 255.

ried under ground forty or fifty years, if the world had been so old. How comes it then, to pass, that no remains are found, no antiquities of those numerous ages preceding the Scripture accounts of time; that no fragments of buildings, no public monuments, no intaglios, cameos, statues, basso-relievos, medals, inscriptions, utensils, or artificial works of any kind, are ever discovered, which may bear testimony to the existence of those mighty empires, those successions of monarchs, heroes, and demigods, for so many thousand years? Let us look forward and suppose ten or twenty thousand years to come, during which time, we will suppose that plagues, famines, wars, and *earthquakes*, shall have made great havoc in the world, is it not highly probable, that at the end of such a period, pillars, vases, and statues, now in being, of granite, or porphyry, or jasper, (stones of such hardness as we know them to have lasted two thousand years above ground, without any considerable alteration,) would bear record of these and past ages? Or that some of our current coins might then be dug up, or old walls, and the foundations of buildings, show themselves, as well as the shells and stones of *the primeval world*, which are preserved down to our times."* This remarkable passage proves that the great man from whom it fell, saw the geological argument in a true light, and felt its force to such a degree as to convince him of the great antiquity of the earth, which he justly viewed as in no way inconsistent with the comparatively recent origin of man, or with the historical account of both events contained in the Genesis. It is easy to understand how such a mind would have been convinced, warmed, and excited even to enthusiasm, by the discoveries that have burst upon us during the last fifty years.

VIII. Organic Remains.—As we descend from the alluvial under our feet, through the strata, the lowest of which lies upon the granite, or the early slates, we are almost never without the records of life, in ages long past, and those records are drawn both from the animal and vegetable world.

Early Animals.—The shells and forms of molluscous and testaceous animals are every where seen; their casts, and their sub-

* Alciphron, or the Minute Philosopher, Vol. II, pp. 84, 85. 1732.

stance, are apparently preserved in stone, but are really converted, by the substitution of mineral matter, into true fossils. Myriads on myriads of these things are found, not merely in the visible, superficial strata, but in the heart of the mountains, and at profound depths, forming an essential part of the solid frame work of the globe. The animals and plants are not accidental resemblances, but authentic specimens of organic antiquity, enclosed in the strata and mountains, as the materials, in mechanical or chemical suspension in the waters, concreted around them. It was impossible that they should be due to any sudden or accidental event; the organic beings came into life, as now—performed their parts as now, and were entombed in the forming masses, which were therefore, of more recent origin.

Fossil Fishes.—If we descend with Agassiz* from the strata of newest formation, to those that lie near, or upon the primary rocks, we are astonished and delighted to find not only that shell fishes and crustaceous and molluscous animals, of various kinds, have existed in the early ages, but that fishes, furnished with fins and vertebræ, have occupied the waters of almost all geological ages, since life began, and that among the earliest, even those that are buried beneath the coal, there were races of great size, power, and ferocity; formidable from their teeth and jaws, which had, in some species, the structure of carnivorous reptiles, and whose forked tails, with unequal flukes, enabled them quickly to turn over on their backs, before striking their prey. The fossil fishes, of particular genera and species, are characteristic of particular geological formations—they extend geographically, far and wide, to distant countries, so that certain species may, if found at all, be expected in similar rocks in Europe, in America, in Asia, and Africa, and they are of every size, from inches and fractions of an inch, to several feet. They occur either solitary, or in groups, or in fragments, or in immense shoals, like those of Mount Bolca, near Verona, in Italy, where there are more than one hundred species; still, not a single fish of the strata that precede the most recent tertiary, is identical in species with any now existing in the waters of the globe.

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* The great writer on fossil ichthyology, of Neufchatel, Switzerland.

Fossil Vegetables.—Vegetables are found in nearly all geological ages, after the granite family, and the labors of Count Sternberg, of Adolphus Brongniart, and others, have proved that a peculiar vegetation, adapted to the temperature, the degree of moisture, and other circumstances of the earth's successive surfaces, attended the different geological epochs.

Splendid and expensive works are now in the hands of geologists, containing exact delineations of the fossil vegetables, as far as they have been ascertained. They are of all dimensions, from minute confervæ and lichens, to gigantic stems; their structure, from mere fragments and ruins, to perfect plants and trees, has been beautifully delineated, roots, trunks, branches and leaves, with the most delicate ramifications of the skeletons of the latter; in some rare cases, the more perishable organic fructification has been made out, and the fruits themselves have been identified.

Vegetation of the Coal Period.—The most exuberant ancient vegetation appears to have been that of the coal period, and its entombed treasures now supply the world with fuel, especially in countries where the forests are exhausted, or where economy of the modern vegetation, or preference for the results of the ancient, decides the choice.

Varieties of the Ancient Fossil Vegetation. — The ancient vegetation appears in many forms, as in that of lignite, of coal, and of siliceous, calcareous, and ferruginous petrifactions, still preserving the structure peculiar to different species; and this has been made still more distinct and satisfactory, by cutting thin slices of the petrified trunks, and grinding them down until they become so thin as to be transparent, when the microscope reveals the internal arrangement of pores and fibres, which characterizes the family. Thus, it has been made to appear, that coniferous trees of forest growth, preceded the coal formation in the south of Scotland and the north of England, and that Zamias, Cycadeæ and other palm-like trees preceded the chalk in the south of England. No species of the ancient world is identical with any one of the modern, and, as has been already remarked, the early vegetation implies, generally, a warm and moist climate, and great fertility of production.

Aquatic Animals—Reptiles.—Animals, almost exclusively marine, attest the great prevalence of the ocean in the earlier geological periods, and it is not until we have passed the coal in the ascending order, that we begin to find reptiles of marine, or amphibious families, and ultimately, still higher up, of terrestrial races. With a similarity of type to the reptile families of the present day, both their genera and species are, however, without a single perfect copy in modern times. Some were carnivorous, and swam in the shallow seas, estuaries, lagoons, and bays, and preyed upon fishes, molluscous animals, and each other. Some lived on land, and were herbivorous, and although a few species, the megalosaurus and iguanodon, for example, were colossal in size and terrible in form, it is probable that the latter of these terrestrial saurians was harmless and inoffensive, while the tooth of the megalosaurus would indicate a ferocious animal of prey, like the marine saurians. Bones of many genera and species of the reptile tribes, especially the saurians, have been found, and of some individuals, entire, or nearly perfect skeletons;—among them, those of vast dimensions have been discovered, enclosed in the solid rocks, along with their petrified and half-digested food, and with their exuviæ, called coprolites.

Marsupials.—If the reptiles formed the transition from the marine animals upward—the marsupials, as they are called, were the link between the ancient reptiles and terrestrial quadrupeds. The marsupials, of which the opossum is an example, receive their young (which, although born, are still immature) into an exterior pouch or abdominal sack, and there nourish them at their paps, until they are fitted to go abroad, and to encounter the vicissitudes of their peculiar modes of life. These are the only animals hitherto found below the Chalk which approximate to the proper terrestrial character. Dr. Mantell has, however, found the bones of birds in the Wealden beneath the Chalk, Dr. Buckland found them or the bones of flying reptiles in the Stonesfield slate, and Prof. Hitchcock has discovered numerous tracks of animals, believed to be those of birds, and possibly of reptiles, some of them of gigantic dimensions, in the new red sandstone of the Connecticut river.

Fossils of the Chalk and Tertiary.—The Chalk then follows, with its immense and varied marine treasures; and then the lower

tertiary, still marine, and then the middle tertiary, where proper and fully characterized terrestrial animals are first found; then, through the remaining beds of tertiary, both marine and fresh water, we find molluscous animals, fishes, reptiles, cetacea and vegetables, verging towards, and even identical with those of our own times. Occasionally we discover also terrestrial animals, but still, different from the modern, until, at last, in the diluvium, and alluvium, and the most recent sedimentary, and concretionary formations, we discern animals and plants, still more and more like those now living, and finally graduating into perfect identity with existing races.

The pages of our author will disclose the great variety and extraordinary form, and, in many cases, colossal dimensions, unrivalled at the present time, of some of the ancient animals, the megatherium, the sivatherium, the dinotherium, the mastodon, the elephant, the hippopotamus, the rhinoceros, the cavern bear, the tiger, and many others. In consequence of the most recent discoveries of geology, we are hurried from that which is stupendous and vast, to that which is inconceivably minute. The extremes of creation meet in the mineral kingdom. In the solid rocks are found both the colossal reptiles, and the microscopic infusorial animalculæ. Ehrenberg has discovered that polishing slate is made up of animalculæ so minute, that forty one thousand millions of them are required to fill a cubic inch, in every grain of which there are one hundred and eighty seven millions, and their siliceous shields are the cause of the well known effects of the tripoli, or rotten stone, in polishing steel, &c. An analogous constitution has been discovered in flint, opal, and bog iron, and the deposits of our modern peat bogs in this country, are filled with similar animalcules, the figures of some of which have been given by Prof. Bailey, in the American Journal of Science, vol. 35, p. 118.

Man no where Fossil.—Man and his works appear only in the last stages, associated with just such beings as now exist, both in the animal and vegetable world.

General Remarks.—Such is an exceedingly general and very imperfect sketch of the progressive creations of animals and plants, that have inhabited our world—have become extinct, and are, in countless myriads, entombed in the rocky strata, and in the solid

mountains. It is only on the upper surface that we discover loose and scattered ruins, either in the soil, or buried in masses of gravel, sand, and clay; ruins of rocks and fragments of strata, along with the relics of animals, trees, and smaller plants, such as we could in any reason, attribute to the catastrophe, or catastrophes of rising and rushing water, the deluges of geologists, or the deluge of the Scriptures; the latter, almost alone, being admitted to the contemplations of those who are uninstructed in our science. Now, it is matter of physical demonstration, that the earth existed for many ages before man was called into being. The whole course of geological investigation proves this view to be the only one that is consistent with the facts. To be convinced of its truth, it is only necessary to become thoroughly acquainted with the innumerable records of a progressive creation and destruction which the earth contains, inscribed on medals, more pregnant with historical truth, and more worthy of confidence, than those that have been formed by man; as much more as nature exceeds in veracity, the erring or mendacious records of the human race.

IX. Some Features in North American Geology.—Probably no country is more favored in the nature, abundance, variety, and distribution of the most important mineral treasures. The limits of these preliminary remarks must prevent even the most general summary of our geological formations, or at most, admit of nothing more than a skeleton; but the materials for information, already abundant, are yearly increasing, as may be seen in the various public reports, in the transactions of learned societies, and in the journals of science.

Of the primary and transition rocks, to which we may add the coal formation and the early secondary, we have immense ranges, extending in a northeasterly and southwesterly direction, through the continent, and comprising most of the minerals and many of the fossils that are found associated with such groups in the old world.

The Alleghanies, (including many mountains having local names,) following the general bearing of N. E. and S. W., and ranging between the Mississippi and the Atlantic, form, with their branches and connected chains, the great rain-shed of the countries east and west, and rising to two, three, four, and five thou-

sand feet and more,* give direction to the streams and rivers, either to the Mississippi, the Atlantic, or the great lakes, and the St. Lawrence.

Rocky Mountains.—In like manner, the far more stupendous chains of the Rocky Mountains, whose loftiest peaks are reported to be between three and five miles high,† give a geological character to the regions east and west, in which directions the waters flow to the Mississippi and to the Pacific, while the other contributions descend to the Gulf of Mexico, and to the Northern Ocean. It is to be regretted, that in the United States proper, there are no mountain ridges or solitary peaks, that pierce the region of perpetual cold.

Mount Washington.—Mount Washington, of the White Mountain group in New Hampshire, which approaches a mile and a quarter in height, being in 44° of north latitude, and on a continent whose average temperature is many degrees below that of Europe, throws off its snowy mantle only for a short season, in July and August, while it is clad in white, during the remaining months of the year. Even on the first day of September, (1837,) as adventurers upon this Alpine mountain,‡ we were, both on its flanks and summit, involved in a wintry tempest of congealed vapor, formed into splendid groups of feathery and branching crystals, unlike to the snows of the lower regions; the driving masses came in fitful gusts, veiling in a white cloud, all objects far and near; but occasionally breaking, admitted a flood of solar light to render visible this hoary pinnacle, and the deep gorges and valleys of the neighboring groups of mountains.

The mountains of Essex county, State of New York, between Lake Champlain and the St. Lawrence, approach the White Mountains in altitude, but no one of them is permanently snow-clad.

Mountains of Central Europe.—It is otherwise in Europe, whose grand central group of Mount Blanc, and the various

* Professor Mitchell, University of Chapel Hill, states that the Black Mountain in North Carolina, is 6476 feet above the level of the ocean. See Am. Journal, Vol. xxxv, No. 2.

† See Professor Renwick's Outlines of Geology.

‡ See Am. Journal of Science, Vol. xxxiv, p. 74.

Alpine mountains, rise far into the region of perpetual congelation; and Mount Blanc would pierce that region even at the equator. Thus is provided an eternal store-house of ice and snow, over whose wintry surface, the winds, rendered heavier by contact, glide into the valleys and plains of the countries at the feet of the mountains, and thus temper even the warm climate of Italy, preventing the extreme vicissitudes which we experience.

But these immense natural magazines have a still more important relation to the irrigation of the vicinal countries. The melting by the heat of summer, supplies copious streams to feed the innumerable rivers that flow from these grand fountains to almost every part of continental Europe, south of the Baltic. Thus, the effects of drought are in a great measure prevented; while destructive mountain floods are of rare occurrence.

From the absence of such mountains, we have no permanent stores of ice and snow, and, consequently, our rivers are liable to extreme variations of altitude and force. The Ohio, in midsummer, sometimes leaves numerous fleets aground, while occasional risings, from deluging rains, aided perhaps by the melting of the snows of vast regions, swell the river to an immense flood, that spurns the barrier of the banks, lays villages and cities under water, and expanding into an internal sea, rushes with wasting violence, over the wide-spread meadows and farms.

For this reason, hydraulic engineering is, in this country, attended with peculiar difficulties, both on account of a deficiency and an excess of water; the former rendering the works inoperative, and the latter invading or sweeping them away.

The future civilized inhabitants of the countries near the Rocky Mountains, (excepting, of course, the immense sandy deserts, which near the eastern slope emulate the sterility of Arabia and Zahara,) will enjoy advantages, in many respects, similar to those of Piedmont, Switzerland, Germany, and France, and it is easy to predict, that peculiar structures, and a peculiar state of society, will be modelled in relation to the sublime physical features of those truly Alpine regions. From this, his native land, we have too much reason to expect, that, despite of the efforts of the benevolent to avert the impending doom, the red man of the forest, not reclaimed to humanity, but abandoned to his fate, will vanish

before the prevailing arts and power, and the still more prevailing seductions of civilized life; the exterminated victim of cupidity and cruelty.

Influence of Geological Structure on Society.—It is perfectly apparent to geologists, that the scenery of a country is not more exactly stamped by its geological formations, than are the manners and employments of its inhabitants. This argument, so beautifully displayed by Dr. Buckland,* with respect to England, is capable of an equally satisfactory application to this country.

New England.—The bleak hills and long winters of New England are unfavorable to the most extensive and profitable agricultural pursuits, while the extensive and deeply indented sea-coasts, abounding with harbors, headlands, rivers and inlets, naturally produce an impulse towards the ocean, which, conspiring with the original adventurous character of the population, sends them roving from the arctic to the antarctic circle, till the wide world is laid under contribution by their enterprise. Their numerous streams and waterfalls furnish the cheapest means for moving machinery, and thus manufactories spring up, wherever, in their expressive phraseology, there is *water power;* and steam supplies local deficiencies of moving force. Ingenuity, conspiring with a general system of education, is excited under such culture, to produce numerous inventions, and hosts of young men seek their fortunes successfully abroad as mechanics, seamen, traders, instructors and politicians, who thus operate powerfully, and, we trust beneficially, on other communities.

Southern States.—The immense tracts of rich alluvium in the southern states—the mildness of the climate—the coasts, less abounding with safe inlets, and often modified by the action of the existing ocean, with a population not originally commercial, give a decided impulse to a vast agriculture, and a few great staples form the chief reliance of the landholders. It is easy to see, that this state of things grows out of the recent secondary, the tertiary, and the alluvial formations, which constitute the ocean barrier from Staten Island to Florida, and from Florida to Texas, extending inland towards the mountains.

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* Bridgewater Treatise.

Western States.—In the west, the boundless fertile prairies and other tracts of productive soil conspire with remoteness from the ocean, to indicate agriculture and pasturage as the main employment of the inhabitants, while exhaustless beds of coal, limestone, plaster of Paris, and iron, and rich deposits of lead, and copper, and salt fountains both numerous and copious, furnish means for a manufacturing, as well as an agricultural population. These pursuits occupy the greater number of the people, while many find a profitable employment in navigating those immense inland seas, the great lakes—and the vast rivers, which run thousands of miles before they mingle with the ocean.

What geologist fails to perceive, that this state of things is the result of the immense lower secondary and transition formations which cover the western states, sustaining portions of tertiary, and like all countries, alluvial depositions. While New England produces granite, marble, and other building materials, of excellent quality, Pennsylvania, with the western and several of the southern and southwestern states, supplies inexhaustible magazines of coal, to prompt and sustain the manufacturing interests of this wide country, and to aid its astonishing navigation by steam, already of unexampled extent on its internal waters, and destined at no distant day, to compete, on the main ocean, in amicable rivalry, with our parent country.

Geological Treasures.—Our coal formations are unrivalled in the whole world, in richness and extent; our iron and lead are in the greatest abundance and excellence; Missouri has mountains of pure oxide of iron, that have no compeers, and there is a fair prospect that copper will also abound in the West. We have regat deposits of limestone and marble, of plaster of Paris, marl, and salt, and of building stones of almost every kind; our soils are so various in quality, and in geographical position, that almost every agricultural production is obtained in abundance. It is obvious then, that we have all the physical elements of national and individual prosperity, and that the blame will be our own, if we do not follow them up by proper moral and intellectual culture, which alone, can render them sources of public and private happiness.

Geological Deficiencies—Upper Secondary.—Of the upper secondary, below the chalk, and above the new red sandstone, lying

higher than the coal, we have no well ascertained strata: rocks of oolitic structure we may have, but it is not ascertained that we have the true oolite of England and continental Europe, nor have we traced the Wealden nor the Lias,* with their colossal animal wonders.

Equivalent of Chalk.—Chalk, properly speaking, appears to be absent from the United States, but there is an equivalent to the chalk formation, containing similar fossils, between the Delaware River and the shores of New Jersey, as well as in various places in the south, and, as we are recently assured, in Missouri.

Absence of Volcanoes.—The principal deficiencies in the geological formations of the United States, are in the absence of active volcanoes, as well as of most of the members of the upper secondary. However delightful, active volcanoes, with their earthquakes and eruptions, may be to speculative geologists, the sober, unscientific population, may well rest quite contented without them, satisfied to barter the sublime and terrific, for quiet and safety. Although the soils formed from decomposed lava are often fertile, and the vine flourishes, and the clusters smile most remarkably, on the flanks, and at the feet of the volcanic mountains of warm countries, these influences are too local to be of much importance to agriculture.

Within the United States proper, including the states and territories beyond the Mississippi, and east of the Alleghany Mountains, there is not, so far as we know, a single active volcano, nor even an unequivocal crater of one that is dormant. It remains yet to be decided, whether in and beyond the Rocky Mountains, quite to the shores of the Pacific Ocean, there are any active volcanoes within our parallels of latitude.

Both north and south of our limits, there are on the Pacific shores and the islands, numerous volcanoes, and it would be strange indeed, if there were none, within our extensive possessions on the same coasts.

Records of fire in the far West.—However this may be, there remains no doubt that fire has done its work, on a great scale, among the Rocky Mountains, and between them and the Pacific;

* It is plain that the lias, so called, in the West, is not the lias of England.

for all our travellers attest the existence of immense regions covered with scoriæ and other decidedly igneous products, as if there had been actual and vast eruptions, within a period too short for decomposition to have reduced those tumefied and semi-vitrified masses to soil.

Trap and Basalt.—Regular formations of trap and of basalt, with symmetrical columns, are common among and beyond the Rocky Mountains, and the rocks of this igneous family are frequent in many parts of the old United States. They abound in New England, New Jersey, and the Carolinas, and, as usual elsewhere, they protrude their dykes among other rocks. We are not aware that they have invaded the coal, as in Europe; but in New England, and especially in New Hampshire, they often divide the primary rocks, cutting even granite mountains from top to bottom; branching out, in many places, with numerous veins either dying away to extinction, or perchance, returning again to the main current after having cut off a portion of the invaded rock. The White Mountains of New Hampshire, abound with such features.

Similar intrusions are found in the mountains of Essex, Lake Champlain, New York, and in many other places, and the primary rocks on the coasts of Massachusetts and Maine, as well as in the interior, are wonderfully cut up, by invading veins and dykes of trap, basalt, porphyry, and even of granite itself.

It appears, also, that in the state of New York, there are similar intrusions of limestone into other rocks, including the primary, and not excepting granite.*

Tertiary Formations.—Our tertiary formations are exceedingly extensive, and are rich in fossils, chiefly of the middle and earlier eras. They bound a large portion of the sea coasts south of New England, quite to the Mexican gulf, and up the Mississippi and Missouri. Oceanic deposits are found also, extending hundreds of miles into the interior from the coasts, where, as well as near the sea, they furnish, in the calcareous marls, inexhaustible resources for agriculture. Even on the shores of New England, there are marine tertiary deposits, as at Gay Head, in Martha's

* See Professor Hall, in the Geological Reports for 1838.

Vineyard, and elsewhere in that vicinity, while there are, in every part of the United States, innumerable inland deposits of fresh water tertiary.

Boulders.—In boulders and rocks of transport, our country, especially in the north, northwest and northeast, abounds; vast regions of older secondary, and of transition, are occupied, more or less, by ruins of primary rocks, some of them of vast size, while the primary countries themselves, and the transition too, are marked by their own *disjecta membra.* We are precluded by our limits, from discussing the causes of their transportation, whether by floods, ice floes, or other motive powers.

Pebbles, gravel and sand, are found here as in other countries, transported and arranged by water.*

X. Classification and Nomenclature of Rocks.—We are gratified that our author, in the fifth edition of his work, has preserved the classification of rocks, to which the geological world has been so long accustomed. The changes that have been, from time to time, proposed by eminent men,—Brongniart, Conybeare and Philips, Lyell and others, have commanded our careful consideration, and we find them, as we might expect, since they are proposed by men of knowledge and talent, supported by powerful reasons; but still these reasons appear to us not sufficiently important to counterbalance the great inconvenience of novel terms, especially as there has been no decisive adoption or approbation of either of the new nomenclatures; nor are most of them free from the objection made to the established language—namely, that of implying theoretical views. It would be easy to prove this by instances cited in illustration; nor does the old language necessarily imply more of theory, than that there is among rocks an order of succession, and that there are also prevailing characteristics, distinguishing the classes of rocks from each other; and so much of theory as this must be admitted by any language that may be adopted, whether the terms are significant or not.

The terms primary, transition, secondary, tertiary, alluvial, diluvial, volcanic, trap, &c., are still in general use, and they are

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* These remarks on American Geology, were inserted also, in an Introduction to Dr. Mantell's Wonders of Geology, first American edition, 1839.

retained even by those who introduce new terms, for the latter must, in order to be intelligible, be translated by means of the former. It is not necessary that every portion of a primary rock should, in its present form, be older than the masses that are generally superincumbent: granite may shoot its veins into the rocks that lie over it, without invalidating its general claim to a prior existence, at least in the form of materials, if not in the present mode of aggregation.

New terms are, with propriety, introduced into geology when they are needed, as into other sciences; thus, the vast secondary is divided into older and newer, or upper and lower; the immense tertiary is now separated into three divisions, older, middle, and newer, or in Mr. Lyell's language, eocene, miocene, and pliocene, and the latter of these is again subdivided into older and newer.

There are, however, limits to the utility of subdivisions; where they are very numerous and minute, and withal founded on theoretical considerations, they may become inconvenient, and produce the confusion they were intended to avoid. This was the fact in the minute details of the Wernerian language, while its leading terms were happily chosen.

If they were first contrived as a key to Werner's peculiar theoretical views, they no longer retain that peculiarity; they are now rather indicative of order and character in the formations, than of a theory of origin; and as this order and these distinctive characters really exist, they may, without inconvenience, be designated by these terms; nor do any terms that have been contrived, appear to us more unobjectionable.

We must concede the propriety of local names for local formations, especially where they are remarkable in their structure and contents. Such is the Wealden in the S. E. of England, the region which Dr. Mantell, and other English geologists, have so admirably illustrated; it is indeed a member of the upper secondary, but it is unique and most interesting in its geological characteristics. Such, also, to some extent, is the Stonesfield slate, a member of the lower oolite and middle secondary, but it presents organic remains, different, in some respects, from those of any other rock—at least, of any one that is coeval.

These local names have, however, been much multiplied, especially in England, where new terms are now proposed for subdivisions of the transition series, for which there exists, indeed, a commanding necessity, rendered apparent by the researches of Mr. Murchison, among the slates of Wales.

XI. Suggestions as to Geological Agents and Geological Theory.—Creation is the work of God. The earth, in common with the whole universe, unfolds volumes filled with proofs of intelligent, wise and benevolent design. The work bears the impress of a mind, omniscient—of energy, omnipotent—of skill, infinite—and of consistency and benevolence—without doubt real and perfect, although not always obvious to our limited faculties.

Without presuming to know, when or how, the act of creation was performed, we may, without presumption, inquire as to the physical powers that were put forth in arranging the materials of the earth, and as to the manner in which they may have operated to produce the grand and multiform results.

Granite—the deepest rock of which we have any knowledge, is not a mechanical deposit; it is made up principally of crystals, or of parts more or less crystalline in structure, mutually adjusted by salient and re-entering angles, or confusedly aggregated; presenting occasional cavities, lined by more perfect crystals. Every thing implies a previous state of corpuscular mobility, the particles having liberty of motion; and the only powers equal to the effect, are heat and electricity, aided by water and the saline, alkaline, acid, and other soluble chemical agents; these we now find abundantly in the constitution of the rocks, and they or their elements were therefore originally provided in the grand storehouse of created materials.

Comparative Agency of Fire, Water and Electricity.—The accumulation of geological evidence leaves no doubt of the prevalence of fire in the interior of the planet; the portion in actual ignition or fusion, in order to be sufficient to feed the host of volcanoes in various parts of the globe, must be very extensive, and the regularly increasing temperature as we descend into the earth—regular on the whole, although accumulating in different ratios, in different places and countries, concurring with

the evidence of volcanoes, fully establishes the dominion of internal fire. Our knowledge of the powers that generate heat, in many modes of chemical and mechanical action, and more than all, by galvanism, renders it entirely credible, that any portion of the crust of the earth, whose origin appears to have been igneous, may have been really derived from that source. Any part of the interior may, therefore, have been melted, and if not now in ignition or fusion, it may readily pass to that condition by a transfer or increased energy of the powers which, even in our comparatively small experiments, are sufficient to generate, instantly, the most intense heat, in the most unfavorable circumstances.

It is extremely probable then, that heat may have wrought those wonders in our earth which demand extensive fluidity—fluidity by fire, rather than by water. Fire and galvanic electricity have this vast advantage over any fluid solvent, namely, that they can render any substances fluid, without the addition of more matter, to that which is to be thus made fluid; the materials themselves become, in a sense, the source of the heat needed to melt them, and it is without doubt that this agent may be sufficient to render the entire planet fluid. This may be granted, without deciding the question, whether it has ever actually been in this condition. Thus far we believe, that the opinions of most geologists will carry them at the present day; and if our views are different from those formerly expressed in connection with this work, the change is the result of conviction founded on adequate evidence.

It is now apparent that heat in the earth is not an accidental occurrence, like our fires kindled on the surface; it is not the result merely of transient combustion; it is an inherent and ever active principle, concentrated at one time in a particular region, and at another time in a different place; now, slumbering for ages, and then revived or transferred, but unextinguished and unextinguishable. It must have been prevalent in early ages in the deep interior of the planet, and indeed all that now bears evidence of an origin from fire, is by far the greater portion of the earth, while the depositions evidently produced by water, and by aqueous solutions, are but a very small film compared with the whole.

Water and Soluble Chemical Agents.—Leaving out of the question, for the present, the geological formations that are evidently aqueous, and are so regarded by all geologists, we are compelled to admit, that in the early periods of the planet the ocean must have prevailed far more extensively than now, if not universally; or, in other words, the existing dry land must have been under water. If granite had been melted under atmospheric pressure alone, or when there was no atmosphere, its surface would have been inflated and porous, like the upper current of lithoid lavas; but, if melted under the pressure of water, it may be of several miles in height, it would, on cooling from fusion, crystallize, and become as we see it, a solid mass. The same remark will apply to sienite, to porphyry, to trap, to serpentine, &c. which are admitted to have had an igneous origin.

Early and Present Ocean.—Now, what properties may we fairly suppose would have belonged to the waters that hovered over the yet embryo islands and continents, still immersed in their native element, before the elevation commenced, by which the dry land was made to appear, and what qualities may we not suppose the present ocean to possess at profound depths, where its pressure is great, and in those places where the heat may also be active and long prevailing.

Modified Properties.—Water, under such circumstances, must evidently be a fluid of very peculiar properties. It must contain all the chemical agents not only that are soluble in it, but also that are soluble in a compound fluid, consisting of water, and of other agents still more active. The acids would be solvents for the alkalies, the metallic oxides, and most of the earths; the alkalies would be solvents for alumina and silica; acids and alkalies may have alternately prevailed; and even if acids, alkalies, earths, and the other metallic oxides, had been present at the same time, and had formed salts, these compounds, so far as they were soluble in water, would also impart to the fluid peculiar solvent powers; while those compounds which were precipitated, would be thus removed, so as not to impede other agencies. In the constitution of mineral bodies, we find all the active chemical agents, oxygen, iodine, chlorine, fluorine; and doubtless bromine will be found; the acids and alkalies are abundant; soda exists

in great quantities; potassa is not unfrequent in minerals, and lithia is found in several. The alkalies are largely, and the alkaline earths are considerably soluble in water; all the earths except silica unite with acids, and even this is easily dissolved by hydro-fluoric acid. Thus all the metallic oxides are soluble, either in acids or alkalies; the metals and combustibles combine readily with oxygen, chlorine, iodine, bromine and fluorine; carbon* and other combustibles become soluble by combination with each other, and with the supporters of combustion.

If the elements came from the hand of the Creator in a state of freedom, their first action must have been attended with intense energy, and innumerable combinations and decompositions would have taken place, the great agents encountering each other at every turn, and thus developing a new order of things.

Solubility of Silica and Alumina.—It is worthy of remark, that quartz, feldspar and mica, the prevailing minerals in granite, gneiss, and mica slate, are composed mainly of silica and alumina. Now silica and alumina are (as already remarked) readily soluble in the fixed alkalies: alumina is soluble in acids; silica in hydro-fluoric acid, and this agent can render silica gaseous. There are notable quantities of potassa and soda in both feldspar and mica, and fluoric acid has been found in the latter; it appears therefore, that those solvents were present at the birth of these minerals, and entered into their constitution. Alkali exists in the earth in vast abundance, and thus even silica and alumina may have been provided with an appropriate solvent.

The solubility of all the existing materials that form the crust of the globe; their solubility either in their elementary forms, or in their proximate or complex combinations, is then a truth clearly demonstrable, and actually demonstrated.

Auxiliary Power of Heat.—The activity of chemical agents, especially if subjected to pressure, is much increased by a high temperature. There can be no reason why we should suppose, that those causes which now feed the fires of more than three hundred active volcanoes, were dormant in the youth of the planet. On the contrary, innumerable extinct or quiescent volcanoes, record the ancient energy and extent of internal fire, which would

* Carbon and chlorine do not unite *directly*, but they combine through the agency of hydrogen in olefiant gas and chloric ether.

operate both as an auxiliary to solution, and in its own proper agency by fusion.

Add to all this, the intense action of the deep seated fires which have melted granite and other igneous rocks, and we find ample evidence both of the direct and auxiliary agency of internal heat.

Before the emergence of the land from the ocean, all volcanoes must have been submarine, as many now are. They would all therefore act under vast pressure, a pressure not even approached by modern experiment, and the heat thus accumulated must have given great activity to water and to aqueous solutions of chemical agents.

Thus both mechanical and chemical laws conspire to produce solution and fusion on the greatest scale, and with the greatest energy. By fusion and softening by fire; by solution and softening by water, and its dissolved chemical agents, which may have been even ignited under the enormous pressure of miles of ocean, we may suppose chemical depositions to have proceeded contemporaneously or in succession; confusedly, as in granite, or in layers, as in gneiss and mica slate; and the imbedded minerals of the primary rocks, the garnets, the staurotides, the tourmalins, the beryls, and others, whose elements were present, crystallized by their affinities, forming first the integrant atoms, whose progressive aggregation produced the beautiful crystalline solids, that in a peculiar manner adorn the early formations of the globe.

Water and fire and pressure, and all the great chemical agents, may thus have conspired, in acccordance with physical laws, in effecting the arrangement of the crust of the planet.

Violent movements were the natural result of this state of things. Igneous agency, the parent of earthquakes, acting beneath the rocks already formed, and beneath the incumbent ocean, would of course produce fractures, dislocations and distortions, tortuous flexions, injections of veins and dykes, heavings, subsidence and elevation of strata, called *faults* by the miners, and innumerable irregularities.

In the same manner many of the trap rocks were probably thrown up beneath the primeval ocean; they broke through the strata and congealed above or between or among them, in ridges, peaks or flats; or they were injected in dykes or veins, or driven, laterally, between the strata, rending them asunder, as if cleft by

wedges. When, after the emergence of land, they burst out beneath the atmosphere, they formed true volcanoes.

Inference.—While, by a vast accumulation of evidence, the claims of heat have been greatly and justly enlarged, and as regards the great mass of the globe, fusion has, by rightful authority, been substituted for solution, Vulcan has thus triumphed over Neptune; but the latter still enjoys no mean dominion, either in extent or in power. It is indeed impossible to explain geological phenomena without having recourse to both these mighty agents, the one ruling the immense interior kingdom, the other the external, through whose superficial territories the restless monarch of fire makes occasional and violent eruptions, establishing often only a transient sway, and after menacing universal destruction, retreating again to his hot domain, leaving merely the vestiges of his destructive aggression. At other times and places the irruption is sustained; age after age, subterranean thunder and agitations celebrate the victory, and a burning signal-light is hung out against the skies, the emblem of conquest by fire.

While we have vindicated the too much neglected effects of water and aqueous solutions in softening, modifying, or dissolving mineral bodies, we are free to confess that the solution of the entire planet, or even of its crust, in water or in any other existing solvent, is a supposition which no well instructed person would now venture to make. Sustained by the paramount authority of Werner, it was long a received doctrine of the geological schools, and it is perhaps not surprising, that his prevailing eloquence and the zeal of his numerous disciples, trained under the very sound of his voice, should have given extensive currency to this theory.

Those who have been among the last to retreat from this untenable ground, have however no cause for mortification, since the converts to the Wernerian theory may find enrolled in their catalogue names of the greatest celebrity for talent, attainments, and moral excellence. This theory, as a whole, is now for the most valid reasons abandoned; still some important members of it will be always retained, and Werner, *clarum et venerabile nomen*, will be ever honored and revered.

XII. First condition of the Materials of the Globe.—Both geology and revelation are silent with respect to the first

condition of the materials of our planet, nor is it possible for us to decide the question how they first appeared. There is however no reason to suppose, that we see any thing as it was originally created. We are certain of this in relation to the rocks containing organized beings and fragments, whether the latter were charged with organized relics or not. This statement includes all formations except the primary or crystallized and igneous. Reasoning from the natural products of volcanoes, and upon the laws of crystallization, as applied to crystalline masses, as well as to individual crystals, no geologist hesitates to infer, that the crystallized and unstratified rocks have assumed their present appearances from the operation of natural laws, and consequently that the globe, as far as we can examine it, or infer its condition at profound depths, has been wrought over, and much of it again and again. Consequently, we cannot be certain that in this sense even granite is strictly primitive; but in relation to subsequent formations, it may be primary or anterior to them; as an igneous rock, it may have been melted in all geological ages, and consequently some of its injections and overflows may have been more recent than the newest secondary rocks, for it has been found penetrating and overlying chalk. This appears to be the most recent geological date which it has been proved to have attained. Still, it would not be surprising if it were found to invade and cover even the tertiary; we ought to be prepared for such discoveries, nor would they, if made, militate with our present views of geological dynamics. Farther than this we are hardly prepared to go, for if that which is granite below were to be erupted above, under only atmospheric pressure, it would assume some of the known forms of lava, and if ejected under the sea, it might take on the character of the traps or porphyries. In all vicissitudes of geological theory, it must ever remain true, that the materials of granite, considered as a whole, have always been below all other existing rocks, and consequently that they are prior in order of position, although their form of existence is not strictly primitive, nor can any thing among rocks be fully proved to be entitled to that name.

Mr. Lyell's name of hypogene implies formed beneath, which is in accordance with the ideas expressed above.

XIII. Possible modes and results of elementary action.—In the present state of chemical science, our elementary ponderable bodies are divided between combustibles, (metallic and non-metallic,) and supporters of combustion—of the former fifty, of the latter five; and if we extend the idea of combustion, as some authors are disposed to do, to other cases of intense chemical action, attended by the extrication of light and heat, we shall include the agency of the combustibles and metals upon each other, as well as upon the proper supporters of combustion, and also the action of the latter upon one another. For our present purpose, it is quite immaterial which view is embraced.

If we suppose that the first condition of the created elements of our planet, was in a state of freedom, and the globe being a mass of uncombined combustibles and metals, that oxygen, chlorine, iodine, bromine, and fluorine were added, it is obvious, that the reaction, awakening energies before dormant, would produce a general and intense ignition and combustion. Phosphorus, potassium and sodium would instantly blaze; the other combustibles and metals would follow in the order of their inflammability, and thus a general conflagration would be the very first step in chemical action. Water would be formed, the atmosphere would result from the mixture of its elements, the fixed and volatile alkalies, the earths, and stones, and rocks, the metallic oxides properly so called, the sulphurets and phosphurets, &c. of the metals and of the combustibles, the principal acids, the iodides, bromides, fluorides, and chlorides, alkaline, earthy and metallic, and ultimately the salts, besides many other compounds resulting either from a primary or secondary action, would be produced.

In such circumstances, the imponderable agents, heat, light, electricity, magnetism, and other forms of attraction, would be inconceivably active—steam, vapors and gases would be suddenly evolved in vast quantities, and with explosive force; and the recently oxidated crust of the earth would be torn with violence. It is however obvious, that this intense action would set bounds to itself; for the chemical combinations would relent or cease, when the crust had become sufficiently thick and firm to protect the metals and combustibles beneath from the water and the air, and other active agents.

As we are merely stating the conditions of a problem, we forbear to descant upon collateral topics, or to pursue the primary rock formations through all their vicissitudes. We do not even aver that such events have actually happened; but philosophy is sober and rational when it assumes that their existence is consistent with the known properties of the chemical elements, and with the operation of physical laws. Supposing that such was the actual beginning and progress of things, it is obvious that the oxidated crust of the globe, would still cover a nucleus consisting of metallic and inflammable matter. Of course, whenever air and water, or saline and acid fluids penetrated to this internal magazine, the same violent action would recur at increasing depths, and the confinement and pressure of the incumbent strata, augmenting the effects a thousand fold, would in later ages, necessarily produce the phenomena of earthquakes and volcanoes.

Still, it is equally obvious, that every recurrence of such events, provided no cause of renewal can be indicated, must oxidize the earth deeper and deeper, and if the point should ever be attained, when water or air ceased to reach the inflammable nucleus, or if it were all oxidized, the phenomena must cease, and every approximation towards this point would render them less frequent.

Does this correspond with the actual history of the globe? Are ignition and convulsions less frequent now than in the early ages of our planet? The extensive regions, occupied by rocks of acknowledged igneous origin, but where fire is not now active, lend support to this hypothesis, which well accords with the views now generally adopted of the formation of granite. This hypothesis is perfectly consistent with the opinion that those galvanic powers which we *know* to exist—whose action we can command, and whose effects, having been first observed within the memory of the present generation, now fill us with astonishment, are constantly active in producing and renewing the phenomena of earthquakes and volcanoes, as both at earlier and later periods, they have been equally efficient in melting granite itself.

Metals and chemical fluids, with juxtaposition, in a certain order, are the common means by which we evolve this wonderful power. Even substances apparently dry and inert, will produce a permanent, and in proportion to the means employed, an energetic

effect, as in the columns of De Luc and Zamboni. Metals and fluids are not indispensable, for almost any substances of different natures properly arranged, will cause the evolution of this power. Whoever has witnessed the overwhelming brilliancy and intense energy of the great galvanic combinations of Davy, Children, and Hare, and considers how trifling in extent are our largest batteries, compared with the vast natural arrangements of earths, salts, metals and fluids, which exist beneath our feet, will not be slow to admit that this power may in the deep interior be incessantly and alternately evolved, mitigated, suppressed, revived, and augmented to tremendous intensity.

In our instruments, we see emanating from this source intense light, irresistible heat, magnetism in great efficiency, and a decomposing agency, which, by direct or intermediate action, commands all elements, and all combinations. The experience of a few years has added magnetism as a power at once the effect and the cause of electricity.

The latter, especially in the galvanic form, evolves immense magnetic energy, and magnets in turn give out electricity and produce all the effects of electrical and galvanic combinations—heat, light, or sparks and ignition, shocks, decomposition, and, by induction, even magnetism itself.

We have stated an hypothesis as to the condition of the elements when they were first created. We would not insist upon this, because we cannot know it to be true. But in assigning galvanic action as a cause of the internal heat of the earth, we propose a reasonable theory, and we provide not only for heat independently of combustion, but we may in this manner provide combustibles which may act chemically, and thus add to the effect without limit. The decomposition of acids, alkalies, earths, and other metallic oxides, is a familiar effect of galvanic action; their metals and combustibles are set at liberty, and some of them being inflammable both in air and water, elastic agents may be evolved, and being rarefied by heat, would produce violent mechanical action. The first principles of this hypothesis are established by experiment, and nothing is really hypothetical but the application to the phenomena of internal heat and of earthquakes and volcanoes.

It is a peculiarity of the present view, that causes are provided which admit of indefinite continuance, and of unlimited renovation, and there appears no reason why the phenomena should ever cease. It has therefore the great Newtonian requisites of a good theory: *its facts are proved*, and *the theory is both true and sufficient.* In its application to volcanoes, it has this additional advantage, it embraces all that is possible in other theories. Coal, lignite, sulphur, petroleum, hydrogen gas, and fermenting pyrites, may all contribute their quota of power to the production of volcanoes, although the united effect of all these must, if it be operative at all, be very trivial. Heat, light, electricity, and magnetism, may produce endless decompositions and recompositions; burnt substances by galvanic energy returning again to their combustible condition, will burn anew; elastic fluids will be evolved in unlimited quantities, and all the violent mechanical effects which their action is known to produce will succeed; these are among the known and familiar effects of this power, and all the materials necessary to render it active are existing in the earth on a scale of immense extent. The present hypothesis does not exclude the subsequent action of water, in dissolving chemically, or disintegrating mechanically, the crust of the globe; for water, fire, and all the great chemical and mechanical agents mutually cooperate.

The cause now indicated is sufficient for all the phenomena, and this cannot be said of any other that has been, or, in the present state of our knowledge, can be named. We may venture a step farther; it is certainly possible,—perhaps it is not improbable, that the light and heat of the sun and of the fixed stars may have a similar origin. To the eye of philosophy, as well as to vulgar apprehension, the sun is an ignited body, and we know not of any power but the electrical that can perpetuate this condition. It is not necessary to speculate as to the mode of excitement, but we may remark, that fluids are not indispensable; the power may be evolved from dry substances, and even between good conductors, if heat be applied in the beginning; electricity may produce heat, and heat may excite electricity, and both have the most intimate and reciprocal relations to magnetism. Thus a circle of agencies is provided which being mutually causes and

effects may continue to operate in an endless cycle whose termination will not be fixed by the exhaustion of phyical power, which never tires nor grows old, and will cease to act only when the Creator shall fix its limit and annul the fiat that called it into being.

XIV. Relation of Geology to the early Scripture History.—In this country, the cultivation of scientific geology is of so recent a date, that many of our most intelligent and well educated people are strangers even to its elements; are unacquainted with its amazing store of facts, and are startled, when any other geological epochs are spoken of than the creation and the deluge. But, it is beyond a doubt, that there are innumerable and decisive proofs of successive revolutions, and of a gradual progress in the course of geological events, implying, on the whole, a regular order in the formation of the crust of the planet, which events necessarily imply much time, and cannot be referred, exclusively, to any course of diluvial action. It is impossible, to refer to this cause, rocks containing consolidated water-worn ruins and fragments, and organized remains, entombed in the firm strata and mountains. The fossil organic kingdom presents a vast field of observation and instruction, and it is less known, even to the greater number of intellectual persons, than almost any department of knowledge. None but geologists study it with diligence, and none who have not made themselves masters of the facts, are qualified to judge of their importance, and of their bearing. To understand the subject, we must study in the fields, in the mines and mountains, or, as an imperfect substitute, in the cabinet. Persons who are entirely ignorant of this species of information, are destitute of the means of forming a correct judgment, they neither know the facts, nor can they compare one truth in geology with another, so as to estimate their mutual relation. On this subject, it is, therefore, very difficult to find access, to many minds, otherwise enlightened, and habituated to receive and weigh evidence, with candor and intelligence. The obvious reason is, that they are not in possession of the first elementary conceptions; and when the facts are stated, if they are not denied, they are neglected, because they are inconsistent with their habits of thought, and because they make no distinct impression,

they are supposed to be dreams or pictures of the imagination; thus they fail to bring that conviction to the mind, which must always be the result, when they are fully understood and realized.

In this country, where the moral feeling of the people is identified with reverence for the Scriptures, the questions are often agitated by intelligent persons,—When did the great series of geological events happen? If the six days of the creation were insufficient in time, and the facts cannot all be referred to the deluge of Noah, to what period, and to what state of things shall we assign them?

This is a fair topic of enquiry, and demands a satisfactory answer; an answer, which is given by the whole series of geological discoveries, and the question will never remain of doubtful issue in the mind of any one who has fully studied and mastered them: but they must be studied profoundly and not superficially. The subject of geology is possessed of such high interest, that it will not be permitted to slumber; it will proceed with increasing energy and success; a great number of powerful minds and immense research are now employed upon it, and many collateral branches of science are made tributary to its progress. Its conclusions have been supposed to jar with the Scripture history; this is contemplated with alarm by many—with displeasure by some, and possibly, by a few with satisfaction; but there is no cause for either state of feeling: the supposed disagreement is not real; it is only apparent. It is founded upon the popular mistake, that since the creation, the deluge and volcanic eruptions, with the convulsions of earthquakes, are the only causes that have produced important geological changes; they believe that this world was formed substantially as we now see it, and if they have any knowledge of its immense and various deposits, they suppose that they were made in a very short period of time. Both these are fundamental errors, which have misled both the learned and the unlearned, and they are still extensively prevalent.

Although the materials were created by almighty power, they were evidently left to the operation of physical laws, which laws also affected, more or less, the fate of the various races of plants and animals that were successively called into existence. But as already remarked, there is no reason to believe, that any part of

the crust of the earth, reaching even to a fathomless depth, is now in the condition in which it was originally made; every portion has been wrought over and brought into new forms, and these changes have arisen from the action of those physical laws which the Creator established, and which are as truly his work, as the materials upon which they operate. The amount of time is the only difficulty, and this will vanish before an enlarged and reasonable view of the whole subject, comprehending also a just estimate of the evidence.

Nature of the evidence.—The evidence is the same which is readily admitted as satisfactory in the case of historical antiquities.

Roman coins, weapons, personal ornaments, utensils, baths, roads, camps and military walls, and defences of various kinds, have been frequently discovered in Britain. They are ascertained to be Roman, by their resemblance to, or identity with, the acknowledged productions of that remarkable people, as still existing in Italy and the adjacent countries, the ancient seat of their dominion. Had Julius Cesar and the other historians and writers been silent as to the invasion of Britain, and as to the dominion, which, for more than four centuries the Romans sustained in that island; still, could any one, acquainted with the facts, hesitate to believe, that they had not only visited Britain, but also remained there, for a great length of time, as conquerors and masters. Had all historical knowledge of these events been lost, would not the antiquary who examined the relics, and who also extended his observations to other countries where similar things are found, with perhaps the addition of splendid aqueducts, temples, and amphitheatres, pronounce that they had all evidently originated from one and the same people, and would he not, without hesitation, pronounce them to have been highly civilized, warlike and powerful; and that their epoch was one of considerable antiquity.

At this moment, there exist in some parts of England, and in various parts of Europe and Asia, ancient barrows or sepulchral mounds, some of them of stupendous size; similar structures are found in North America, and also stupendous forts, which, in Ohio and Kentucky, and other western states, amaze and confound the observer.

These structures enable us to realize the supposition just made respecting the Romans, and compel us to say, that all these massy mounds and forts, were the work of unknown races of men, on whose history even tradition sheds not a ray of light, and we are left in profound ignorance, as to their origin.

In relation to geology, it is easy to make the case still stronger. When, in 1738, the workmen, in excavating a well,* struck upon the theatre of Herculaneum, which had reposed, for more than sixteen centuries, beneath the lava of Vesuvius; when, subsequently, (1748,) Pompeii was disencumbered of its volcanic ashes and cinders, and thus two cities were brought to light; had history been quite silent respecting their existence, as it was respecting their destruction;† would not all observers say, and have not all actually said,—here are the works of man, his temples, his forums, his amphitheatres, his tombs, his shops of traffic and of arts, his houses, furniture, pictures, and personal ornaments, his streets, with their pavements and wheel-marks, worn in the solid stone, his coins, his grinding mills, his wine, food, and medicines, his dungeons, and stocks, with the skeletons of the prisoners chained in their awful solitudes, and here and there the bones of a victim, who, although at liberty, was overtaken by the fiery storm, while others were quietly buried in their domestic retreats; the falling cinders and ashes even copied, as they fell, the delicate outline of female forms, and having concreted, they thus remain true volcanic casts to be seen by remote generations.

Because the soil had formed, and grass and trees had grown, and successive generations of men had unconsciously walked, tilled the ground, or built their houses, over the entombed cities; and because they were covered by lava or cinders, does any one hesitate to admit, that they were once real cities, that at the time of their destruction they stood upon what was then the upper surface, that their streets once rang with the noise of business, their halls and theatres with the voice of pleasure: that, in an evil hour, they were overwhelmed by a volcanic tempest from

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* Earlier excavations had been made and three female statues discovered.

† In the histories of those times, it is only said, in general terms, that cities and villages were overwhelmed.

Vesuvius, and their name and place, for almost seventeen centuries, blotted out from the earth and forgotten.

The tragical story is legibly perused by every observer, and all alike, whether learned or unlearned, agree in the conclusions to be drawn. When moreover, the traveller of the present day sees the cracks in the walls of the houses of Pompeii, and observes that some of them have been thrown out of the perpendicular, and have been repaired, and shored up, he learns that the fatal convulsion was not the first, and that the doomed cities, must have been before shaken on their foundations, by the throes of the laboring earth.

To establish all this, it is of no decisive importance that scholars have gleaned, here and there, a fragment from ancient Roman classics, to show that such cities once existed; and that they were overthrown by the eruption of the year 79 of the Christian era, which gave occasion for the interesting letter of the younger Pliny, describing the death of his uncle, while observing the volcanic phenomena, his philosophical curiosity having cost him his life. In such cases, the coincidences of historical and other writings, and the gleanings of tradition, are indeed valuable and gratifying; they are even of great utility, not in proving the events, for of them there is a record, which cannot deceive, but in fixing the order, and the time of the occurrences. The nature of the catastrophe, which buried the devoted cities, is however perfectly intelligible, from the appearances themselves, and needs no historical confirmation. No man ever imagined that Herculaneum and Pompeii, were created where we now find their ruins; no one hazards the absurd conjecture that they are a lusus naturæ, but all unite in giving an explanation consistent alike with geology, history, and common sense.

Application of the Evidence.—In the same manner then, we reason respecting the physical phenomena of our planet, and here, even at the hazard of some repetition, we shall make a statement of facts, to illustrate this most important argument, which will demonstrate that geological evidence is of the same nature with that just cited, and that the most revered documents cannot be more decisive in relation to civil history, than geological facts are with reference to the natural history of the earth.

The earth then is full of crystals and crystallized rocks; it is replete with the entombed remains of animals and vegetables, from entire trees to lichens, fuci and ferns—from coal beds to mere impressions of plants; it is stored with animals, from the minutest shell fish, and microscopic animalculæ, to gigantic reptiles; it is chequered with fragments, from fine sand to enormous blocks of stone; it shews on the joining surfaces of many strata, and especially of the sandstones, the delicate flexions, produced by undulating water, when the materials were loose as they are now on the sea-shore; it exhibits in the materials of its solid strata, every degree of attrition, from the slightest abrasion of a sharp edge or angle, to the perfect rounding which produces globes and spheroidal forms of exquisite finish; it abounds with dislocations and fractures; with injections and fillings up of fissures with foreign rocky matter; with elevations and depressions of strata, in every position, from horizontal to vertical; it is covered with the wreck and ruins of its upper surface; and finally, its ancient fires, sometimes for variable periods, partially dormant and relenting, have never been extinguished, but still struggle for exit, through more than three hundred volcanic mouths. The present crust is therefore only the result of the conflicting energies of physical forces, governed by fixed laws; its changes began, from the dawn of the creation, and they will not cease till its materials and its natural powers are annihilated.

Instances.—They are innumerable, and are every where at hand; every system of geology unfolds them; our author's preceding volume is rich in such facts, and it remains only to illustrate our position by a few examples, duly connected, to sustain the argument, for which purpose they are added.

Fossil Fish of Mount Bolca.—The beautiful fossil fish,* more than 100 species of which are found in marly limestone, in Mount Bolca, near Verona in Italy, inform us that they were once living and active beings; before those hills were deposited, and when the waters stood over the place where, in the bottom of the sea, the fish were entombed, the rock which contains their skeletons

* Already cited in the general sketch; from this celebrated locality there are splendid specimens in the cabinet of Yale College.

was formed around them, doubtless in the state of a calcareous and argillaceous sediment; this calcareous stratum (perhaps itself thrown up by a volcanic heave, and thus suddenly enclosing the fishes) was then overwhelmed by a submarine eruption of molten rock, and the heat was not communicated through the bad conducting substance of the marl, to the destruction of the organic forms; then again, and still on the bottom of the sea, the calcareous rock was formed anew with its enclosed fish; again the molten rock flowed over the calcareous marl, and so on in several successions. But this is not all; this remarkable formation is now 50 miles from the Adriatic, the nearest sea, and it rises 1200 feet above it. It is plain then, not only that the whole was successively formed beneath the ocean, but that the hill, with the country to which it belongs, was afterwards raised by the power of subterranean heat, thus emerging from the surrounding waters, and ages since becoming dry land.

To illustrate this case, we will state that in the waters of the harbor of Newport, in Rhode Island, there are one hundred and thirty or more species of indigenous fishes;* now suppose an irruption, as from land torrents or a volcanic movement under the waters, were to throw suddenly upon them, such a mass of sedimentary mud, that they were to become entangled and suffocated on the spot; they would of course remain, and the materials might, by pressure and time, become consolidated around them. Were the bottom of the sea to be afterwards elevated into dry land, on opening the bed, there would be found a true Bolca quarry of fossil fish. Excepting the overflow of igneous rock and the repetition of the fish deposit, and of the fire rock, the cases appear exactly alike.

The Bolca fish present only one example among thousands in Italy and Sicily, of the emergence of mountain ranges, whose flanks for a thousand feet or more in height, as on the Apennines, or two thousand as in Sicily, are replete with the shell fish and other molluscous animals of the Mediterranean.

Organic Remains in Early Rocks.—In very early, and often deeply seated rocks, usually called the transition, coming imme-

* As ascertained, from the fishermen, at the instance of the late President Dwight, by my brother Gold S. Silliman, then a citizen of Newport.

diately after the primary, we find the first traces of organized beings; the perfect impresses of plants, with the earliest coal, and both the forms and the entire mineralized bodies of millions of animals; the deposition of these rocks was therefore cotemporary with, or subsequent to, the creation and propagation of the organized beings whose impresses or whose forms they contain, and it is self-evident, that these rocks could not have been deposited prior to the date of the animals and vegetables included in them.

In many cases both the plants and animals lived and died at or near the places where they are found entombed in the rocks; for often they present few or no marks of violence, or of accident; their delicate parts are often perfectly preserved; animals, with their organs entire, and plants with their fibres and leaves in full expansion.

Occasionally, however, we find one stratum with its included mineralized organic bodies entire, and a contiguous one having them more or less broken, mutilated and dispersed. It is therefore evident, that in early ages, as now, organic relics were transported and broken by currents and other aqueous movements, and by atmospheric agitations, and that perfect repose was only occasional and existed in peculiar circumstances, while between the extremes of great movements and entire quiet, there were, as at the present time, many intermediate stages.

Both the plants and animals belong to races which are no longer found alive, or if *analogous* races exist, they are related to the ancient ones only by class or genus, and not by species. Orthoceræ and trilobites are found among the most ancient animals, and zoophytes, shell fish, and other molluscs are common. Madrepores and crinoidea abound in the early rocks. Sometimes, strata rich in entombed animals, occupy great districts of country. In the transition marble for instance, animals reposing in the bowels of mountains, miles from day-light, often form almost the entire mass, and they are so firmly united to the rock, as to constitute a part of its substance. Many of the architectural marbles owe much of their beauty to imbedded animals, myriads of which lie almost in absolute contact; the matter of the rock between them, only filling up the void occasioned by their angular and confused positions.

The trilobites had a jointed articulation, could bend their bodies like a lobster, and we find them sometimes doubled, and sometimes expanded, as they lie in the rocks. Dr. Buckland has shewn that the eye of this animal was furnished with 400 lenses, adapted to a wide range of vision in clear water, and consequently it was not fitted to live in the turbid ocean formerly supposed to belong to this geological period—the imaginary chaos. Dr. Buckland's Bridgewater Treatise is a classic on organic remains, and no one having the knowledge and giving the attention necessary to comprehend his fine course of illustration and argument, can fail to find in his book a moral and physical demonstration of the highest order; physical, as proving the progressive formation of the crust of the earth through a long course of ages, and moral, as evincing the wise and benevolent design which is irresistibly inferred from the work of progressive creation and arrangement.

We have already mentioned the fossil fishes below the coal, and in the deep transition rocks still lower down. The former opinion that the early animals were exclusively very simple in their structure, appears therefore, no longer tenable. Still it is true, that as the creation advanced, higher orders of both animals and plants were called into being, while animals of simple structure are also continued to the present time.

Possible Mode of Consolidation.—There is little difficulty in understanding how the marine animals—for example, the crinoidea and corals that fill, more or less, the transition limestone of the Peak of Derbyshire, and the limestone of many portions of the West in the United States, came to be thus entombed. We cannot doubt that the animals received their existence, and lived and died in the ocean, and that, at least at the time of their death, it was full of calcareous carbonate, either in solution or in mechanical suspension, or both. When they died, they of course subsided to the bottom, and were surrounded, as they lay, by the concreting calcareous matter. Multitudes of them were present, at the same time and place, in all the confusion of accidental position, and therefore were enveloped, just as we find them, in every imaginable posture; the interstices were filled by the lime, and this being more or less chemically dissolved, produced a firm sub-crys-
...ne mass, a section of which shews us the animals sawn
...*ph,* and admitting of a polish, like the rest of the rock.

If we could suppose that our common clams and oysters, that lie in the mud of our harbors and inlets, were to become solidified into one mass, along with the matter which envelopes them, the case would not be dissimilar; only they would be enveloped in earthy, instead of crystalline matter, and the rock formed from it would be referred to the most recent secondary, or to the tertiary, unless its texture were afterwards altered by igneous agencies, by infiltration of dissolved matter, or other causes, and even then, its geological age would be decided rather by its organic remains, than by its mineral texture.

It is easily understood, also, how a new stratum, either of the same or of different constitution, may be deposited upon a previous one, and with it, the bodies of the animals that lived and died in the fluid, by which it was covered; and these might be the same animals with those of a previous stratum, or of a different order, it being understood that, in the case of marine animals, each successive stratum was, in its turn, the bottom of the existing ocean, and also the upper or last consolidated layer of the crust of the earth, as it then was at that place. A similar course of reasoning will apply to fresh-water deposits.

With respect to marine and aquatic animals, the temperature, and perhaps the mineral contents of the waters, appear to have been, at different periods, adapted to the support of different races, which were therefore called into existence, and thus, when they died, their remains became successively solidified.

There was not, however, an entire extinction of all the animals of a particular race; a multitude were entombed, as is proved by their remains, but the species often survived to another epoch or to other epochs, sometimes through a cycle of changes; in the mean time, new races were created and became petrified in the forming rocks: again perhaps, the diminished race peopled the waters anew, and their relics were solidified in another deposition, and so on in succession.

Whether animals and vegetables were deposited in the ocean, or in seas, in lakes, rivers or estuaries, it is easy to imagine, that if all the causes necessary to produce the events were to be brought into successive operation, they might follow each other in the order supposed; and that this was the fact, cannot be reasonably doubted, any more than that an edifice, having granite

for its foundation, sandstone for its basement, marble for its superstructure, wood for its roof, and lead, zinc or iron for its covering, was actually constructed by the architect, and connected in that order by his intelligent design.

The great truths of geology are few, simple and intelligible; needing nothing but the application of a sound judgment, enlightened by science, to the accurate observation of facts; the order of their succession can be often ascertained, and not unfrequently the proximate causes and the immediate circumstances can be discovered and satisfactorily explained.

It is a supposition, altogether inadmissible, and unworthy of a serious answer, that the animal and vegetable races, entombed in such profusion, and buried often under entire mountain ranges, or firmly cemented into their very bosom, were created as we find them; and still more preposterous is the suggestion sometimes made, by those ignorant of geology, that there are no real organic relics, but only illusory resemblances to animals and plants. Both suggestions are absurd, and evince only profound ignorance. To any person well informed in geology, it is quite superfluous to assert that organic relics were once living beings, performing the part belonging to their respective races, and that at their death, or soon after, they were consolidated, in the then concreting and forming rocky strata, or that they were, in various instances, overwhelmed by igneous or diluvial catastrophes.

Animal Remains in Secondary and other Rocks.—The older secondary rocks often abound in shells of molluscous animals, principally of extinct genera, and there is a progression through the more recent strata, exhibiting a greater and greater approximation towards the more complicated structure of the most perfect animals; while the newer rocks of this class, and of the strata that lie upon them, including the tertiary, contain reptiles, fish, and even birds, and terrestrial quadrupeds.

Saurians and Lizards.—The extinct saurians or lizards, mentioned already in our general sketch, appear to have been mainly coeval with the period between the coal and the chalk, or the early tertiary. They were the most conspicuous animals of that time, and were evidently very numerous. Several genera, including many species, and a great number of individuals, have been discovered, and among them are the most colossal bones that have

hitherto been found, anterior to the middle tertiary, or perhaps to any periods.

These ancient saurian families, namely, the crocodiles, the ichthyosauri or fish lizards, the megalosauri or great lizards, the plesiosauri or animals resembling lizards, and several more, have been found in the middle and recent secondary tertiary rocks, especially of England and France, and some of them have been discovered in this country.

The megalosaurus is found in limestones and sandstones lying higher than the lias, and the ichthyosaurus and plesiosaurus, in many of the strata above, and in some of those below that rock.

The fossil crocodile appears to have been, anciently, as at present, an inhabitant of fresh water, and of rivers. In the West Indies, according to De la Beche, the crocodiles frequent muddy, and sometimes brackish ponds; and in shallows, they often remain for hours, with the tips of their noses out of water. The crocodile has been continued, perhaps, from the new red sandstone—certainly from the lias, to the present time—and as its remains often occur in the interval, it appears to have been a tolerably constant inhabitant of our globe.

The organization and habits of crocodiles do not enable them to contend with the agitations of the sea, which they shun. It would seem, however, that the organization of the ichthyosauri, and perhaps of the plesiosauri, would enable them to swim in the waves.

With the solitary exception of two species of the opossum, found in the Stonesfield slate near Oxford, England, no viviparous vertebrated animal has been found below the chalk. The Stonesfield slate belongs to the older rocks of the oolitic series, and lies above the lias.

The remains of the saurians indicate animals of various size, from a yard or two to twenty, forty, fifty, and seventy feet or more in length. Being generally amphibious, there is every reason to believe, that when only portions of England, in the form of islands, stood above the water, these animals swam and sported about in the interlocking waters of early Britain, or basked upon the beaches of its seas and estuaries, while the terrestrial lizards, some of which were of gigantic dimensions, either preyed on other animals, or cropped the exuberant tropical vegetation of

a glowing climate, that flourished either on the dry land or along the fenny and sedgy shores.

The iguanodon, (so called from the resemblance of his teeth and form to those of the iguana of the West Indies,) was an herbivorous reptile, and appears to have attained the length of seventy or eighty feet or more, with a height of nine or ten feet. Still, his remains are interred in solid ferruginous sandstone, far below the chalk, and probably more than two thousand feet beneath the upper strata of chalk and tertiary, that were subsequently formed over him, most of which have been swept away by diluvial action or by other causes.

In July, 1832, another saurian was discovered in the sandstone of Tilgate Forest.* It is described and figured by Dr. Mantell in the Geology of the South East of England. The reptile is named the *hylæosaurus*, or Wealden lizard. Vertebræ, ribs, coracoids, and other bones were found, either in connexion or in juxta position, making an imposing mass, and very firmly cemented in the sandstone. The animal is supposed to have been twenty five feet long.

The vegetable remains, as well as the fishes and shells, and rolled stones, that are found entombed in the same strata, prove that they were once the upper surface, and formed part of a vast estuary, which was subsequently buried by the marine formation of the chalk and its attendant strata.

Early Animals, Vegetables, and Coal.—Among the primary rocks there are no traces of vegetation any more than of animal life. According to De la Beche, wood and terrestrial plants are found in most rocks, not only from the old red sandstone upwards, but in the transition beneath; proving, that dry land must have existed, more or less, previous to, or at the time of the formation of most of these rocks. We may suppose, therefore, that ponds, lakes and rivers, existed also.

It would appear, from the relics of the periods immediately succeeding the transition rocks, that vegetation had increased prodigiously upon the earth, and that there were even trees and forests upon those parts of the surface that had become sufficiently dry.

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* Subsequently at a later geological period, that of the green sand beneath the chalk at Maidstone.

Bituminous coal was formed from submerged and inhumed vegetables, among which, cryptogamous plants, whose vestiges are numerous in the coal mines, were conspicuous.

Coal, with all its alternating and attendant strata of shales, sandstones, limestones, clays, iron ores, puddingstones, &c., is often found repeated several times in the same coal basin or coal field; in extreme cases fifty, sixty, or seventy times or more; and the mines are occasionally worked to a great depth, (even to a thousand feet in some places in England.) It is plain, therefore, that no sudden and transient event, like a deluge, could have produced such deposits, although it might bury wood and trees, which, in the course of time, might approximate to the condition of lignite or bituminized, or partially mineralized wood, which is often found under circumstances indicating a diluvial origin.

Two very interesting facts have been recently observed in this country, illustrating the origin of coal from vegetables. Peat has been found in Maine, converted into coal; large trees have been discovered buried beneath the alluvial sand and clay of the Mississippi; some of them retain the marks of the axe, but are changed in part into coal, and still present perfect wood in parts of the same log.—Amer. Journal, Vol. xxxv, Dr. C. T. Jackson—Prof. Carpenter.

Arborescent plants, and their branches and roots, are often found in the coal formations, and in their sandstones, &c., thus proving that the gigantic vegetables were sometimes embraced in those deposits.

Early existence of Trees.—It had been supposed, that the plants which have contributed to the formation of coal were generally succulent, with little or no firm woody fibre. It appears, however, from two memoirs by H. Witham, Esq., of Edinburgh, that large trees, strongly resembling the Norway fir and the yew tree, existed, even anterior to the deposition of the great bituminous coal field of the Lothians, around Edinburgh. Near that city, in 1826, a fossil tree was discovered, three feet in diameter at its base and thirty six feet long, lying nearly horizontally between the strata of sandstone. Its composition was carbonate of lime 60, oxide of iron 18, carbon 9, alumina 10.

In the quarry of Craigleith, near Edinburgh, another fossil tree has been recently uncovered, whose geological position is in the mountain limestone, and considerably below the great coal basin of the Lothians. Its elevation is seventy five feet above the level of the sea, and its roots were in the bottom of the quarry. The length of the stem was forty seven feet—a large branchless trunk, —in some parts much flattened, so as to afford an elliptical section. At the largest place, its diameter was five feet by two, and at the smallest, nineteen inches by sixteen. Its branches, and many feet of its top, are gone; it was probably sixty feet long, and the incumbent mass of sandstone appears to have been one hundred feet thick; the bark is converted into coal. The composition of this tree is, carbonate of lime 62, carbonate of iron 33, carbon 5, with the specific gravity 2.87. It was a conifer.

In the great coal field of the North, in Britain, fossil plants are usually found lying parallel to the strata, but much broken and compressed, and their parts scattered; but some vigorous plants, generally Sigillariæ, appear to have been so strong as to resist the torrents and to remain in their natural position.

It results from Mr. Witham's discoveries, that gymnospermous phanerogamic plants are much more frequent in the coal formations than has been imagined, and that proper trees, of true ligneous fibre, and of great size, existed even earlier than the bituminous coal.*

Fossil Forest of Portland.—In quarrying in the oolite limestone of the island of Portland in the English channel, the workmen discovered an ancient soil, which they called the *dirt-bed*, and it still bears that name, or sometimes *dirt and black dirt.* It is from twelve to eighteen inches thick, and darkened by lignite. It contains numerous rounded stones from three to nine inches in diameter. In this dirt bed are buried many silicified trunks of coniferous and tropical trees, the latter, palm-like in character, and allied to the Zamia and Cycas. They were evidently fossilized where they grew, as the stumps of the trees stand erect for a height of from one foot to three, and in a single instance even six, with their roots attached to the soil, and about as near to each other

* American Journal, Vol. xxv, p. 109.

as in modern forests. The carbonaceous matter is most abundant around the stumps and around the remains of the fossil Cycadeæ. The dirt bed contains also prostrate silicified stems of trees, partly buried by the black earth and partly by a calcareo-siliceous slate that covers the dirt bed.

Although the fragments of the prostrate trees are rarely more than three or four feet in length, still by uniting many pieces, trunks have been restored to the length of twenty to twenty three feet, or, as Dr. Mantell states, upwards of thirty feet, the stems being imbedded from seventeen to twenty feet, and then forked; the diameter of these near the root is about one foot, and the descent of the roots into the subjacent Portland stone, shows that its strata were soft and impressible when these trees grew. The calcareous slate which covers the trees, was deposited with tranquillity, and forms swelling masses over the tops of the stumps. These strata are found elsewhere: at Lullworth cave, in Dorsetshire, they are inclined at an angle of 45°, and still sustaining the trees in an inclined position, but at right angles to the strata.

From these facts it is inferred that the oolite, full of marine shells, became dry land—its upper surface then became covered by a forest in which grew the tropical plants, the Zamia and Cycas; that the land, with its forests, sank and was submerged beneath a body of fresh water, which deposited a calcareous sediment, with fluviatile limestones, (the Purbeck beds,) deposited quietly, as the water was not disturbed. Two other carbonaceous beds have been found below, and one of these containing Cycadeæ. Mr. Lyell has summed up these changes thus:* "There must have been first, the sea, in which the corals and shells of the oolite grew; then land, which supported a vegetable soil with Cycadeæ; then a lake, or estuary, in which fresh-water strata were deposited; then again land on which other Cycadeæ and a forest of dicotyledonous trees flourished; then a second submergence under fresh water, in which the Wealden strata were gradually formed; and finally, in the cretaceous period a return over the same space of the ocean."

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* Elements, p. 358.

Then might be added the tertiary strata, both marine and fresh water, and finally the alluvial and diluvial.

To imagine, adds Mr. Lyell, such a series of events, will appear visionary and extravagant to some who are not aware that similar changes occur in the ordinary course of nature; and that large areas near the sea are now subject to be laid dry, and then submerged, after remaining for years covered with houses and trees.

More recent Fossil Trees and Plants.—Among the more recent secondary rocks, vegetables increase in quantity and variety as we approach the tertiary, in which we find inhumed wood in the form of lignite, or bituminized wood, or wood slightly mineralized; eventually we find wood unchanged, although inhumed, and finally peat and living plants; and thus we trace the vegetable families, from their commencement on the borders of the primary, quite down to our own times. In the loose sand, gravel, and detritus, we often find trees, at every depth, between the surface of the ground and the fixed rocks below; the surface is often covered by boulders of travelled stones, and the deposition is evidently diluvial.

Organized Remains deposited from Water, but not from a Transient Deluge.—It is scarcely possible to doubt, that the process of animal and vegetable decomposition in a mineralized state, described above, was that which really happened. Whatever may have been the operations of fire at preceding or subsequent periods, it is impossible that it should have been concerned in the immediate formation of the mineral strata, which contain numerous organized remains. Animals or vegetables could never be produced or sustained in the midst of fire; and indeed, it is quite incredible, that strata, containing their relics, were ever melted; nor is it easy to imagine, that they could be even softened, in any great degree, without destroying or materially deranging the organized structure.

Strata of shale or clay might, indeed, be baked without fusion, so as to assume a stony hardness, and still preserve organic impressions. Thus we have observed a common hard baked brick, lying in a pavement, bearing a distinct and beautiful impression of a scallop shell, (Pecten;) the shell was gone, being doubtless destroyed by the fire, while its impress remained. Strata that have

been ignited may, therefore, retain the forms of organic bodies, which would of course be destroyed by the heat.

This fact is indeed fully illustrated by every ornamental impression made by a mould or die upon the clay of unbaked pottery or porcelain; it remains indelible and unalterable after passing through the furnace.

It appears evident also, that the mineralized plants and animals of the solid strata have not been collected in these situations by any sudden and local, or even general catastrophe; for, as an author remarks, "among the immense number of fossil shells, many are remarkable for their extreme thinness, delicacy and minuteness of parts, few of which have been injured, but on the contrary they are, in general, most perfectly preserved." Among the plants of the coal formation, situated sometimes hundreds and thousands of feet below the surface, and covered by many beds of solid rocks, their leaves, many of which are of the most tender and delicate structure, are often found fully expanded, in their natural position, in regard to the rest of the plant, and laid out with as much precision as in the *hortus siccus* of a botanist. It is often true that the minutest parts do not appear to have suffered attrition or injury of any kind.

Fragmentary Rocks.—The rocks composed of fragments and rounded water-worn pebbles afford us the strongest evidence of progressive destruction, deposition and consolidation.

Among the transition rocks we find, in general, for the first time, fragments both rounded and angular of all the previous rocks; sometimes these fragments are united by crystalline matter of a different nature, forming the paste or cement which holds them together; or the paste is composed of nearly or quite the same materials with the fragments, but in a state of much finer division, and at other times there is little interposed matter.

Many of the rocks of this class are most palpably fragmentary, the fragments being of all sizes, either scarcely visible to the naked eye, or several inches or feet in diameter.

Instances.—We have seen and carefully examined, in place, all the following instances of fragmentary rocks, namely:—The brecciated marble of the Potomac, employed in the public buildings at Washington; this is a remarkably firm rock, composed of angu-

lar and ovoidal pebbles, the latter of which have evidently received their shape from friction in water. The cement is a more minutely divided substance of the same kind; but calcareous matter is not exclusively the material either of the pebbles or of the cement.

The fragmentary rocks of Rhode Island, extending by Providence to Boston, and which are very conspicuous in Dorchester, Roxbury, Brooklyn, and other neighboring towns, are fine examples of early formations of this kind. They are very interesting five miles east of Newport, at a place called Purgatory, where a large mass of the rock is separated by the natural seams, that appear to have been produced by a subterranean heave. The seams run parallel for a great distance, cutting the pebbles in two, and thus the included mass has fallen out, having been undermined by the sea, whose waves, when impelled by storms, break and roar frightfully in this deep chasm.

The pebbles are here chiefly quartz; they are ovoidal in form and of every size, from that of a bird's egg to that of a barrel, and they lie generally with their transverse diameters parallel. They are frequently invested by numerous crystals of the magnetic oxide of iron, perhaps sublimed by the heat that elevated the strata.

The pebbles of the fragmentary rocks about Boston are very various in their composition, but are obviously the ruins chiefly of primary rocks. The pebbles, which there lie in the roads and fields, have proceeded from the disintegration of this puddingstone.

The great sandstone deposit of the valley of the Connecticut presents every variety in the size and form of the parts that have been broken up from previous rocks, transported, more or less rolled, and cemented into rock again.

In East Haven, near New Haven, the rocks often contain massy pebbles of granite, gneiss, mica slate and clay slate, and of the individual minerals of which they are composed. Water-worn pebbles are in some places as common in these rocks as on the sea shore: they form mighty strata, which have been tilted out of the horizontal position, into an inclination of 15 or 20 degrees from the horizon; their successive parallel ridges resemble the waves of the sea, and between them are the long-drawn troughs, extending with great regularity in the direction of the strata.

The Catskills, are conspicuous monuments of geological revolutions, for not only at the base, but at the summit, from two to four thousand feet above the level of the Hudson River, we find them composed extensively of fragmentary rocks, rounded and angular; their rude piles inform us, that the materials of which they are built were once loose and rolling about, in the waves of an early ocean, encountering friction and violence in their various modes of action, and it admits of not the smallest doubt that these mountains, after consolidation, have been raised from the depths of the sea into their present position—lifted doubtless with the continent of which they form a conspicuous feature.

Origin.—We must look for an adequate cause whence arose the mighty masses of ruins of every shape and variety, composing not merely accidental fragments, or here or there a stratum or a hill, but covering myriads of square miles, the foundation of countries, and rising occasionally even into high mountains.

Such are the effects and proofs of crystallization, as exhibited in the primary rocks, that the contrast afforded by the fragmentary piles, must appear very striking; and connected with their relative position, can leave no doubt on the mind, that they arose from a subsequent and totally different state of things.

What were the causes that broke up portions of the primary rocks and left their ruins the sport of the waves, destined in the progress of time, to be cemented again into firm masses?

Causes which appear very feeble in their action produce, by long continuance, results which we are sometimes inclined to attribute to more violent agents. Such are the wearing effects of the weather and the seasons, and of the vicissitudes of temperature, powers constantly in operation, and to these we can add the convulsions of earthquake, tempest, flood, and fire, by which our planet is still as it has ever been agitated. These causes would, in the course of ages, perform the work, great as the results may now appear.

The breaking up of primary and other rocks by ordinary causes, as well as by violent convulsions, and the transportation of their ruins, often to distant places; the frequently rounded form of the fragments, presenting pebbles of every size, from that of a pea, to that of a hen's egg, a human head, or a barrel—quartz being not

unfrequently the material; the reconsolidation of these masses into firm rocks—their stratification at first horizontal and then rising, at various angles of inclination; the alternation of such strata with slate and coal and other deposits, their extraneous contents of innumerable organized beings, and the elevation of the whole, sometimes hundreds or thousands of feet above the ocean level; all these facts leave not a doubt that the fragmentary rocks required much time for their formation, consolidation and elevation, and could never have been the work of a short period, or of a transient deluge. It is evident also, that some of the brecciated rocks were deposited before the granite mountains broke through them, tilted them up, and threw them into positions of high inclination, as may be seen in various places among the Alps.

Diluvial Deposits.—As regards the wreck and ruins with which the surface of our planet is every where covered; their extraordinary position, and to some extent their production, have been usually, but as is now thought too generally and exclusively, attributed to diluvial agency; to mighty floods and rushing torrents of water.

Diluvium is found every where. The almost universal deposits of rolled pebbles, and boulders of rocks, not only on the margin of the oceans, seas, lakes, and rivers; but their existence, often in enormous quantities, in situations quite removed from large waters; inland, imbedded in high banks, or scattered, occasionally in profusion, on the face of almost every region, and sometimes on the tops and declivities of mountains, as well as in the valleys between them; their entire difference, in many cases, from the rocks in the country where they lie—rounded masses, and pebbles of primary rocks, being deposited in secondary and tertiary regions, and vice versa; these, and a multitude of similar facts, are among the most interesting of geological occurrences. Curvilinear stones may possibly, in given instances, be formed by decomposition of the angular portions, and by various chemical agencies, aiding those of a mechanical nature; but pebbles present unquestionable evidence of having been brought to their rounded form by friction in water, aided by sand and gravel and by mutual collision, and they can scarcely be confounded with those produced in any other way.

The attrition of the common waters of the earth, within the limited period of our observation, aided by transient and occasional floods, or even by the deluge described in Genesis, would do very little towards producing so mighty a result; and we must assign the effects not only to our own times, but to an earlier and much more extended course of mechanical agencies, produced by agitated waters, through successive ages.

We must charge to moving waters the undulating appearance of stratified sand and gravel, often observed in every country, and very conspicuously in the plain of New Haven; in remarkable beauty and delicacy in many places in the valley of the Connecticut River, and especially at Mink Brook, a mile or two below Dartmouth College; exhibiting frequently a delicacy of flexion in the layers, which makes them appear as if they had, but a moment before, received their impulse and position from undulating currents, and as if they had copied the very eddies and gyrations of the wave.*

Indeed nothing in geology strikes the observer with more interest, than these beautiful arrangements in strata, of the beds of sand, gravel, clay, loam and pebbles.† A section of a bank of any of these deposits—or better still, an avulsion or fall, which leaves the stratification exposed, without being obscured by the rubbish, produced by digging, or by the sliding of loose sand—never fails to exhibit the effects of sedimentary deposition; sometimes horizontal—sometimes inclined at various angles, great or small—sometimes undulatory, and recording, in a language that cannot be misunderstood, the effects of subsiding water. The beds are not always arranged in the order of the magnitude of the parts. Sometimes coarser gravel, or even pebbles, will form a layer above fine sand, and then perhaps the order will be reversed, indicating that there were currents, and these, relenting and increasing alternately, as they were impelled probably by tides or storms, so that coarser or finer materials were transported and deposited, as the waters and currents were more or less agitated and rapid.

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* These strata would perhaps be now arranged with the tertiary.

† For our present purpose it is immaterial whether these depositions be referred to tertiary deposits, or to those that are strictly diluvial.

Bowlder stones, consisting of fragments of primary rocks, probably from the regions north of the great lakes, are found abundantly on the secondary regions of Ohio, New York, and other states; the fragments of the primary Alps, on the Jura chain, the ruins of the Scandinavian Mountains on the secondary and diluvial plains of Prussia and Northern Germany, (the Baltic intervening,) and the fragments of the northern counties of England, cover the southern and middle regions.

In many cases bowlders and pebbles can be traced to their native beds, and frequently they are strangers to the regions where they are found.*

Deserts of sand, covering tracts more or less extensive, such as those in South Africa, in the Zahara, stretching in a vast belt, from the Atlantic ocean to the desert of Lybia; the sandy plains of Arabia, Germany, and Russia; the great desert at the foot of the Rocky Mountains, and all similar deposits, in situations where no obvious existing causes could leave them, are usually referred to diluvial agency. It is suggested however by Dr. MacCulloch, that the sands may in various cases have been derived from the decomposition of rocks in situ.

Diluvial Torrents—Lakes—Valleys.—That diluvial torrents, especially when aided by convulsions and by ice, have had sufficient power to roll even bowlder stones and disjointed columns† to great distances, or to precipitate them from their native ledges into the valleys, is sufficiently evident, from what we know of the energy of torrents in our own time.

Beds of sand, gravel, clay, loam, pebbles, and bowlders, compose the loose materials of every country, and they invariably exhibit the appearance of deposition from water, sometimes tranquil, sometimes more or less agitated.

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* Erratic bowlders are rarely found in lower latitudes than about 40° in either hemisphere, and they become more abundant as the latitude increases, thus indicating transports by currents of floating ice, freighted with rocks, from the polar regions.—*Lyell's Elements, (p.* 173,*) quoting Darwin.*

† Such as the columns of trap, sometimes of enormous size, which are found scattered, up and down, through the great Connecticut valley, often at a great distance from their parent ridges. The most remarkable case in this range, is ten miles west of Hartford, on the Albany turnpike.—*See Tour to Quebec.*

Moving waters appear to have first transported, and then, in a state of comparative quietude, to have arranged these masses by sedimentary deposition.

The effects of diluvial devastation are in a considerable degree veiled, by the gradual depositions of sedimentary matter, during the decline of the velocity of the moving waters.

Granting that the crust of the earth has been covered by water, which has been in any way withdrawn, or that the land has been lifted from a state of submersion in an ocean, there must evidently have resulted a multitude of local lakes, determined in their form and position by the basin shape so often traced by contiguous hills and high grounds; in these, separate and independent deposits might have been going on for a length of time. Those lakes that had no permanent supply of water, would, of course, be exhausted by soakage and by evaporation: others would burst their barriers, or gradually wear them down, and during their escape, produce diluvial ravages; while those only would be perennial, which were fed by streams and springs.

Many valleys of denudation, as they are called by Prof. Buckland, were probably produced by diluvial action, aided by convulsions. Such valleys are conspicuously seen in the South of England, on the channel coast, where similar strata are found capping contiguous hills, projecting at their sides, and running beneath their foundations; a curve or hollow having been scooped out between, thus indicating the effects of great rushing torrents, preceded or attended perhaps by earthquakes that, more or less, broke up the superficial strata.*

Many valleys were doubtless produced in this manner; and others by great diversity of causes.

Extraneous Contents of the Diluvium.—In all countries, where curiosity and intelligence exist, single bones, and entire skeletons of the larger animals, often of extinct species, but chiefly of known genera, are found abundantly in the diluvium.

Whales, sharks, and other fishes; crocodiles, and other amphibia; the mastodon, the mammoth or extinct elephant, and other species of elephants, approaching to or quite like those of modern times;

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* Reliquiæ Diluvianæ.

the rhinoceros, the hippopotamus; hyenas, tigers, deer, horses; various species of the bovine family, and a multitude more, are found in the diluvium, or in the tertiary, at a greater or less depth; and in all the variety of circumstances in which they may be supposed to have been buried, either by ordinary occurrences, or by a catastrophe such as a sudden and violent deluge.

It appears, from Dr. H. H. Hayden's Geological Essays, that under the diluvium of the Atlantic portion of the middle and southern states, there lie buried great quantities of the bones of whales, sharks, porpoises, mastodons, Asiatic elephants, and other large animals, along with numerous trees, sometimes retaining their fruit. Layers of marine mud are also found, deep in the diluvium, beneath the present low water mark.

There are also vast deposits of shells, and especially of a gigantic oyster, in many parts of the southern states. They are found, not only in digging for wells, but they form great beds in various places.*

Near Tours, in France, is a stratum of oyster shells twenty seven miles long and twenty feet thick.

But the collections in the southern states far exceed this. A stratum on the whole continuous, although mixed more or less, with the general diluvium and other materials of the country, has been traced from the Eutaw Springs, in South Carolina, to the Chickasaw country; six hundred miles in length, by ten, or from that to one hundred in breadth.†

There can be no doubt that many of the beds of oyster shells, which have been attributed to the aboriginal Indians of this country are diluviul or tertiary deposits.

The bones and skeletons of large animals, especially of the mastodon and mammoth, are found in wide dispersion, and in very remote countries, in both Americas, in Europe, and in Asia. In northern Asia, the tusks of the extinct elephant or mammoth are discovered in the banks of almost every river, and the ivory is found in such abundance, as to be a regular article of commerce. An enormous carcase of the northern or extinct Asiatic elephant, by the gradual thawing of the frozen bank in which it was imbedded,

* Many of the cases cited are doubtless in the tertiary.

† We suppose these to belong rather to the tertiary.

high above the water, fell down a few years since, and exhibited the flesh in full preservation; the long bristly hair and vast massy hide, requiring a large number of men to carry it, afforded proof irrefragable, of the existence of the animal in those rigorous climates, and of his sudden extinction, inhumation and congelation, with so little interval of time, that putrefaction had not commenced, and has not since taken place, during a succession of ages.

It has been a favorite view with the religious world, that the deluge of the Bible was the cause of the wide dispersion and sepulture of the extinct gigantic races, whose remains are found in diluvium in the various quarters of the world, and that whole races of animals were thus extinguished, and their bodies buried in the wreck of the planet. Such a scene of devastation was thought to be well fitted to produce these effects, as it was certainly ill adapted to the comparatively tranquil life and death of the successive generations of marine and aqueous animals, that peopled the earlier oceans.

A more extended and careful examination, and a more scrupulous weighing of evidence has, however, induced most geologists, including those who have the greatest reverence for the Scriptures, greatly to modify these opinions. While all agree that the extinction of races of animals, in various cases, by deluges, is not only possible but probable, it is admitted that a multitude of the animals whose remains are found, perished by ordinary events, by miring, by accidental drowning, by mutual warfare, by disease, by old age, and by the prowess of the hunter, while the natural and usual movement of the waters of the earth, aided by the accumulations of time, may have effected their sepulture.

That all lands have been elevated from beneath the waters, and that some parts of the world have been repeatedly submerged and raised is, on grounds strictly geological, believed by all geologists; nor can we hesitate to admit also that flowing if not rushing waters, have passed over the surface of all countries; hence such effects as are appropriate to a general deluge are noticed in every region. Shall we add to this roll the following facts, cited on credible authority? The skeleton of a whale lies on the top of the mountain Sandhorn, three thousand feet high, on the coast of the Northern Sea.

So late as June, 1824, the remains of a whale were found on the westernmost Stappen, a mountain in Finmarck, at an elevation of eight hundred feet above the ocean. The bones, reported to be vertebræ, were lost by shipwreck on their passage to England. Similar remains are said to exist also in North Fugeloe, another mountain in those regions.—*Penn.*

While it may be supposed that there is no cause, except a deluge, that could have conveyed the whales to those elevations, it may perhaps be admitted by some, that the rising of the land may have brought up the skeletons, as Mr. Lyell supposes that bowlder stones may have fallen from sea cliffs, and being rounded in the ocean, have been then lifted into daylight.

If the elevation of land from the deep be admitted—and the fact is unquestionable—then it follows of course, that when the bottom of the sea, with its varieties of surface, of plains, valleys, hills, and mountains, is raised above the water so as to become dry land, then every thing that was lying in the abyss must be brought into view, or within the reach of exploration, and in this manner most interesting disclosures may in future eras be made.

Contrast between Diluvial, and Tranquil Aqueous Agency.—The agency of water, whether fresh or salt, in sustaining, depositing, and burying organized bodies in solid rock, (except the effects of occasional convulsions,) was, evidently, tranquil and long continued; giving time for many generations of the same or of different races, and for all the alternations and successions of the strata with different organized bodies.

The occasional intervention of igneous irruption, whether submarine or subterrene, below, or among, or upon the strata of aqueous origin, only increases the necessity of time, and when these coincidences occur, they add to the evidence of grand geological cycles.

But diluvial agency is usually violent, sudden, and of short duration.

If the universal deluge recorded in Genesis, be taken as a type of diluvial action, and the time and the elevation stated in the history, as measured by existing mountains, be taken into the account, nothing could be more violent, destructive, and overwhelming; and certainly upon the face of the earth are every where

recorded in legible characters, the necessary physical effects of such a debacle.

It has entered but little into the views of any except geologists to discriminate between these two classes of effects. They are as wide apart as possible, and nothing in science is more unskilful or more unhappy than to confound them, as is constantly done by the unlearned in geology, who are intent on attributing all geological effects to the deluge.

The surface of our planet has, either at one period or many, been swept by violent, agitated torrents of water, which covered the earth every where with its own ruins, but probably cataclysms did not form any of the firm strata filled with organized remains.

Volcanoes.—Their probable causes have been already mentioned in our view of elementary action, and it is sufficient for our present purpose briefly to advert to volcanoes as striking physical features of the earth. Active volcanoes are well known; their causes are now, as they have ever been, in operation, and lava beds and currents are constantly forming in many countries, so that, in one region or another, the earth is never free from volcanic action cognizable by the senses. The products of volcanoes often bear, in their very texture and features, palpable marks of the agency of fire, and thus they inform us, in very intelligible language, that they are indeed ignigenous: even when these features are not distinctly legible, it often happens that the geographical and geological position of the masses does not permit us to entertain a doubt of their volcanic origin. Although they may form beds of solid rock, which have no appearance of scoriæ, cinders, glass, or gaseous inflation, except, perhaps, on their upper surfaces, we still observe their currents, and recognize their birth by fire. Volcanic currents overflow whatever lies in their way, and therefore we find them covering, occasionally, every geological formation, and every work of man.

The superincumbent mass is, therefore, of more recent origin than that upon which it lies. The evidence presented by the eruptions of active volcanoes, and the igneous formations which they produce, goes then to establish the truth of geological succession, but does not imply that its events are more ancient than the masses which are covered.

Extinct Volcanoes.—Formerly extinct volcanoes were vaguely referred to, but without decisive proof of their real igneous origin. Many uninstructed persons were formerly ready to find extinct volcanoes in conical hills, especially if they had a hollow on the summit; and porous stones, of whatever kind, were referred to a similar origin. It was a very captivating and sublime idea, that volcanic fire, still bursting forth, in many places, with destructive energy, had, in times long past, exerted agencies still more extensive—covering provinces with ruins, and operating even in the bed of the primeval oceans. Still the speculation was regarded as somewhat visionary till the middle of the last century, when the subject of extinct volcanoes began to be investigated with accuracy and skill.

It will be sufficient to name the so much disputed country of Auvergne, Velay, and Viverais, in France, which has been often examined by able geologists; and now no one visits that region without being convinced that it is of volcanic origin. This district lies upon the river Rhone, nearly in the angle formed by it with the Mediterranean, and covers a square area of forty or fifty leagues in diameter.

Craters, regularly formed, often entire, sometimes with the thin and scorified edge of the lip in fine preservation, and occasionally of vast dimensions; here, black, rugged and scathed with fire—there, overgrown with trees, and there, filled with water; dykes of solid rock cutting through the volcanic cones; currents of lava, lying where they flowed from the crater, or where they burst from the sides or foot of the ruptured mountain, extending many miles and many leagues, traceable directly to their source, winding along the gorges and the sinuosities of the valleys, now and then diverted from their course by rocks, hills, and other obstacles; sometimes damming up rivers, whose beds they have crossed or obstructed, and thus forming lakes of considerable dimensions; exhibiting all the varieties of lithoid lava, from that which is compact like rock, to that which is, in a greater or less degree, porous and vesicular; crowned or mixed with slag, scoriæ, pumice, olivine, and other products of known and active volcanoes; displaying frequently a structure, now spherical, ovoidal and concentric; now prismatic and columnar, and fronting

streams, and bounding valleys, with ranges of columns, equalling or rivalling the regularity of the basaltic colonnades of Fingal's Cave and the Giant's Causeway: such are a few of the most striking features of these countries, which are so affluent in proofs of igneous origin, that there is nothing needed but to select, carefully and judiciously, those facts which will be the most decisive, especially with respect to minds not familiar with geological subjects.

The volcanoes of the Auvergne, &c., are regarded as of different ages; some appear to have been active before the formation of the present valleys, and some since; where the currents of lava have been cut through, by those causes which formed the present valleys, they are then obviously older than the valleys, and where these currents have flowed into valleys, beds of rivers, &c., they are as evidently of a more recent date.

Although the formation of these volcanic regions was anterior to the records of history, still their epoch was evidently subsequent to the creation of organized beings, which are found imbedded in the volcanic tufa.

The recent researches of Humboldt, "have greatly extended our knowledge of the volcanic tracts of our globe; he has shown the whole country round the Caspian to be a vast district of this nature, a 'pays cratere,' exactly resembling, in its general outlines, the telescopic appearance of the moon; he has also pointed out another great seat of volcanic action, the chain of Thion Chou, south of the Altai, and running about lat. 42° N. and between 70° and 80° E. long. from London. This vast ignigenous district extends over two thousand five hundred square leagues, and being generally remote from every sea, it evinces that marine contiguity, although a common, is by no means an indispensable concomitant of volcanic action."*

For our purpose it is not necessary to go any farther into detail with respect to this class of rocks. All that is true of modern eruptions from active volcanoes, considered as proofs of succession in geological events, is true in the present case. Every thing was occasionally covered by the currents that issued from the an-

* Discourse of Prof. Conybeare on Geology, at Oxford University, 1832.

cient volcanoes, and there is no reason to doubt, that, as happens in connexion with modern volcanic convulsions, destructive earthquakes preceded and attended their eruptions.

Having already thrown out some suggestions with respect to the theory of volcanoes, we shall only remark with Conybeare, that "it is impossible to propose any probable theory of volcanic phenomena which does not, at the same time, embrace the entire structure of the globe, in all its generality."*

The truth of this remark is already realized, for, not only trap, porphyry, and pitchstone, but serpentine and soapstone, and even granite, are now universally admitted to be of igneous origin.

The intrusion of the igneous rocks among those that are superincumbent, producing dykes and veins, often much ramified and frequently metalliferous; the elevation and disruption of the upper strata; the confusion often induced among them; the chemical changes produced upon the contiguous masses, and the profuse and rich crystallization of many of the primary rocks, both in their own proper minerals and in foreign imbedded ones: all these afford decisive proofs of geological order, event, succession, and time sufficient for the phenomena.

Crystallization in Rocks.—No person in the least acquainted with the subject, hesitates to admit that crystallization implies a previous state of corpuscular freedom, either in fluidity, in fusion, in vapor, or at least in a state of softness or diminished cohesion. Although crystallization is not confined to any one geological period, it is eminently conspicuous in the primary rocks.

It presents to a practiced eye and an instructed mind, very decisive proofs that the particles have been in that state of *mobility* which left them at liberty to unite according to fixed laws; the heterogeneous masses being connected by chemical, and the homogeneous by mechanical attraction. Thus in feldspar, (if we include both its necessary and occasional constituents,) oxygen is an element in all the binary compounds that enter into its constitution; in the silica it is united to silicium; in the potassa to potassium; in the soda to sodium; in the lime to calcium, and in the usual contaminating oxide, to iron. Supposing these to be the ultimate elements of the mineral, the proximate principles

* Discourse at Oxford, 1832.

would be produced, first by their uniting, chemically, and in definite weights, to form these binary compounds; which would still farther unite, but still chemically, to form the integrant particles of the mineral, and these particles united mechanically by cohesion, would form the mineral itself.

The same reasoning may be applied to every variety of crystallized rocks and minerals. Limestone, consisting for its immediate principles, of lime, carbonic acid and water, contains, for its ultimate elements, according to the present state of our knowledge, calcium, carbon, hydrogen and oxygen; the latter principle being united with each of the former ones, so as to produce the lime, (oxygen and calcium,) the carbonic acid, (carbon and oxygen,) and the water, (oxygen and hydrogen.) If the limestone were a magnesian one, then we must add oxygen and magnesium, and so of other earths, as silica, or alumina, if they were present.

In our introductory remarks we have observed, that how far back, and how near to the isolated, independent state, we are to trace the elements, we cannot determine. Whether they were created in perfect freedom, or whether combined in pairs, and those pairs again united to form complex results, we can never know with certainty, and all our suggestions on this subject are necessarily hypothetical. But the principles are true, and the statements might easily be extended to the most complex rocks, and to all their imbedded minerals; but without going into all these details, we may reason both intelligibly and conclusively upon the act or process, which, according to physical laws, may have preceded the concretion of the materials of the primary rocks.

Suppose a previous state of chemical mobility by fire to have rendered it possible that the elements of granite should unite; a simultaneous formation of the different minerals must of course happen; the quartzy particles must find their fellows, those of feldspar and mica would do the same, and the three minerals, born at the same moment, might repose in the same cradle. In the same manner, their ornamental companions, (not essential to the rock, butoften studding it like gems set in royal robes)—the emeralds, the topazes, the garnets, the tourmalines, and other crystallized minerals, which sparkling in the bosom of the primary rocks declare a coeval birth, may have had a similar origin.

True it is, that creative power could call the rocks into being, without any arranging process in their parts, but no analogy countenances the truth of such a supposition, and neither moral nor physical reasons oblige us to admit so improbable a supposition.

Who has contemplated the stupendous garnets of Fahlun—the equally gigantic quartz and feldspar crystals of the Alps—the more delicate emeralds of Brazil and Ethiopia—the variously colored tourmalines of Chesterfield and Goshen, Mass., and of Paris in Maine—the idocrases of Vesuvius—the rubies and sapphires of Ceylon and other regions of India—the bubbles of air included with water and other fluids in quartz—the fibres of amianthus—the crystals of titanium—the filaments of native copper and silver shut up in the same mineral—the successive crystallizations of galena, sulphate of barytes, calcareous spar, quartz and fluor spar, especially of Derbyshire and Cumberland, often included in one group—the splendid amethystine and other geodes—little grottoes lined with polished and beautiful geometrical figures—who with a skilful eye and an enlightened mind has seen such things, the ornaments of our cabinets, and has doubted that they were as truly the products of crystallization as any of those of art which are formed in our laboratories, and that both result from the operation of the physical laws established by the Creator.

Crystallization is indeed not exclusively the attribute of primary regions, but in them it is eminently conspicuous; and if we find crystals in every geological age, we are thus furnished with proof that these agencies continued to operate, although with less frequency and energy, through all succeeding periods, and that they have not ceased even in our own times,* for mine-

* I have obtained crystals of calcareous spar, of sulphate of barytes, and of sulphate of lime, and some of them repeatedly, as accidental results in chemical processes: I have seen even quartz crystals form rapidly under my eye, and others have cited them as slowly produced with regularity and beauty from the fluoric solution of silex. Crystals of pyroxene, specular iron, titanium, and other minerals have been produced by volcanic and furnace heat; more than forty species of minerals have been observed in the slags of furnaces, and white pyroxene has been produced by the action of fire upon the constituents of this mineral, and after fusion, it has re-crystallized in the same form.—*Am. Jour. Vol.* 10, p. 190.

ral crystals are every moment forming around us from solution, from fusion, from gas and vapor, and from the unceasing energy of galvanic power.

Still we do not find in the upper secondary rocks, much less in the tertiary, the numerous and grand crystals that are common in the primary, and even to a degree in the transition and early secondary formations, nor do we expect to find grand crystal cavities, *fours a cristaux*, as they have been fancifully called by Patrin, except in the ancient mountains and in the veins and beds by which they are intersected.

No person who has been conversant with chemical effects can easily confound them with those of mere mechanical deposition. Take a piece of the most beautiful granite—its quartz is translucent, if not transparent; its feldspar is foliated in structure, presenting two regular cleavage planes united at definite angles; its mica is perfectly foliated, and splits into innumerable thin laminæ, each of which is transparent and has a high lustre, and this last property is common (sometimes in a less degree) to the quartz and the feldspar. Gneiss and mica slate and saccharoidal limestone are distinguished, in a greater or less degree, by similar characteristics. Now translucency, transparency, lustre, cleavage-planes, and regular structure, are known and established results of chemical deposition, and are never the effect of mechanical aggregation. Compare the above properties with those found in a piece of clay, and no person, however unskilled in physical characteristics, can possibly attribute them to a similar origin. The latter has as obviously sprung from mechanical as the former from chemical laws; mechanical suspension must have preceded the one, and solution, fusion, sublimation, or galvanic secretion the other.

Crystallization is the most exalted agency of the mineral kingdom, and it answers to organization in the animal and vegetable. It results in the production of regular solids, often of beautiful figures, bounded almost always by plane faces, which constitute the outline of beauty in the mineral world, as the curve line does in the organized kingdoms.—*Haüy.*

Proximate Causes of Crystallization in the Earth.—As crystallization by natural laws is constantly going on around us, so

we can at pleasure form crystals of many substances; in some cases, we produce those that never have been discovered in nature, and in others we can surpass them in size and beauty; nor is there any reason to doubt that we could always imitate natural crystals, provided we were acquainted with all the powers and circumstances which operated in the original crystallization of mineral bodies. The discovery of Mr. Crosse, by which galvanic power has been made efficient in producing various crystallized minerals and metallic bodies, affords us a precious light on this subject, and as the galvanic power resides within the earth we feel assured that in all ages it has proved an efficient agent in crystallization. In all the geological epochs after granite, there is decisive evidence of great mechanical changes, operating first on the primary rocks, to produce the materials for the derivative rocks, which are again worn and broken and their ruins are aggregated in rocks still more recent; all such formations exhibit unquestionable proofs of mechanical destruction and mechanical formation; in a word, of changes from the pristine state of the materials, greater than crystallization implies in relation to the constituent or integrant particles, which we may presume to have been originally created.

Werner supposed that the crust of the earth had been dissolved in water, but the solution theory, once almost universally prevalent, has now given way to the igneous, which not stopping with actual or extinct volcanoes, or with trap, porphyry, and pitchstone, has taken possession of the granite mountains and of the very center of the earth. Still, it is admitted generally by geologists that the ocean has for a long time occupied all countries; and it is now evident also, that ignition and fusion on a great scale have always existed in the earth; this is conceded even by those who do not believe in the fusion of the central nucleus. The deep internal fires of our planet have been the most energetic, as would appear from the admitted fusion of granite, and they appear to have been most extensive in the earliest periods. Both in ancient and modern times volcanic mountains and islands have risen from the bosom of the ocean, and volcanic islands are still existing where in former ages the sea raged uncontrolled. The submarine volcanoes also occasionally project smoke, flames, and red hot stones through

the ocean, thus informing us that water cannot always subdue fire, that even now, there are strata at the bottom of the sea where extreme ignition and extreme hydrostatic pressure operate conjointly upon the firm materials, and that both, aided by the principal chemical agents which we know to exist in the constitution of our globe, may unite to produce results of which our trifling experiments can give us but a feeble conception. An attempt, for instance, to dissolve granite by boiling it in water, is just as rational as the effort to melt it in a common fire; neither experiment can possibly succeed; but the former would not prove that granite was never dissolved, nor the latter that granite was never melted; because, the circumstances which may have operated in the interior of the earth are not under our control, and our experiments are therefore inconclusive. We can melt a little granite by the compound blowpipe, and could we command this heat on an extensive scale, we might melt the granite mountains.

We should accept with equal readiness the aid of fire or water, or other agents, as they may appear best adapted to explain the phenomena.

In volcanic countries, silica is certainly dissolved by hot alkaline water under great hydrostatic and steam pressure, and granite is as certainly fused in the intense heat of deep seated fire. There is the best reason to believe, that in the lavas not only granite but all rocks are occasionally melted. If this be true of the proper crystals of granite, it may be also true of the imbedded crystals which it contains, and therefore of all other crystals.

Those which contain much water of crystallization may present a serious difficulty, but perhaps pressure may have retained the water and as the parts of the mineral concreted, in cooling, the molecules of water may have taken their place in the regular solid. Still we can see no reason for excluding water and other dissolving agents, acting with intense energy, under vast pressure and at the heat of even high ignition, from playing a very important part in crystallization.

If we give granite to igneous fusion it is hardly possible to avoid admitting the conjoined action of water and fire on the crystallized slaty rocks that usually cover it; the rocks that are now called metamorphic by Mr. Lyell, because he supposes that their

materials may have been first deposited mechanically and then chemically crystallized by heat acting under vast pressure.

Nature and Application of the Argument.—It is we trust obvious that we have been occupied, not in the superfluous labor of giving a system, a work which is ably done by our author, but in selecting a few facts from the principal geological classes and epochs, to evince that our planet, before it was inhabited by man, was subjected to a long course of formation and arrangement, the object of which evidently was, to fit it for the reception, first of plants and animals, and finally of the human race. This is the sole object which we have had in view in our citations of geological facts, all of which go to prove that the world is not eternal. For in that remote period of which he who recorded the fact probably knew not the date:—*In the beginning* God created the heavens and the earth, and established the physical laws, the ordinances of heaven, by which the material world was to be governed.

The earliest condition of the surface of the planet appears to have been that of a dark abyss of waters of unknown depth and continuance, which repressed the deep seated forces of internal fires.

The structure of the crust affords decisive evidence of a long series of events, in relation both to the formation of rocks, and to the creation and succession of organized bodies, which exist in the strata and mountains in such astonishing quantities.

Succession and revolution are plainly recorded in the earth; and sacred history expressly states that the events involved both order and extent of time.

Geology cannot decide on the amount of years or ages, but it assures us that there was enough to cover all the events connected with the formation of the mineral masses, and with the succession of the generations of living beings, whose remains are found preserved in them.

It is obvious that ages must have passed while the various geological events, which are recorded in the structure of the earth, were happening, and particularly while the innumerable organic beings that had been created, lived, perpetuated their race, died, were entombed and preserved in the rocks, and this through a

vast succession of generations of an immense number of families, genera and species.

As already suggested, (page 510,) we will not inquire whether almighty power inserted plants and animals in mineral masses, and was thus exerted, without design or end, in working a long series of useless and therefore incredible miracles. Can any rational man believe, for example, that many genera of fishes, with vertebræ and fins, and therefore created to live in water, like those of the present day, were placed by mere sovereign power in the slates and other rocks beneath the coal and therefore (as these formations exist in England and supposing all to be present that belong above) nearly two miles below the present surface; or that the iguanodon, with his gigantic form, seventy to eighty feet in length, ten in height, and fifteen in girth, was created in the midst of consolidated sandstone, and placed down one or two thousand feet from the surface of the earth, in a rock composed of ruins and fragments, and containing fish, vegetables, shells, and rolled pebbles! With such persons we can sustain no discussion, since there is no common ground on which we can meet: we must leave them to their own reflections, for they cannot be influenced by reason and sound argument, and can, with or without evidence, believe any thing that accords with their prepossessions. And yet we have known such individuals—those who either deny the best established facts, or endeavor to avoid their effect by making the most absurd suppositions, inconsistent alike with the truths of science, and with candor and fair dealing in argument.

Persons there are, also, who endeavor to do away the argument derived from organic remains, by denying their reality. They affect to regard them, as a lusus naturæ, which phrase, if it has any meaning, would imply, that the relics are not real, but only bear an accidental resemblance to plants or animals. This resort is too ridiculous to deserve refutation, and no individual would hazard such an explanation, who had been in the slightest degree acquainted with fossils, those beautiful medals of past ages. They have been, by the operation of natural laws, laid by, and preserved in the solid strata of the earth, as authentic and imperishable monuments both of the progress of the mineral formations, and of the numerous creations of animals and plants that occupied the suc-

cessive surfaces of the planet before man was called into being; nor did the record cease to be enrolled when man appeared—it was, and is, and will be continued, as long as the earth shall exist.

The order of the physical events, discovered by geology, is substantially the same as that recorded by the sacred historian; that is, as far as the latter has gone, for it was evidently no part of his object to enter any farther into details than to state that the world was the work of God, and thus he was led to mention the principal divisions of natural things, as they were successively created. It is sufficient therefore that there is a general correspondence, which is indeed, in the great features, exceedingly striking, and deficient only in less important particulars not to be expected in so general a narrative, written chiefly for moral purposes; but it is in no respect contradictory to facts.

The Bible is not a book of physical science, and its allusions to physical subjects are necessarily adapted to common apprehensions. Still, the creation and the deluge, although they have a momentous moral bearing, were, *in their nature*, entirely physical operations. Why should any one refuse to attend to a history of these two stupendous events, merely because that history professes to have proceeded from the same author as the work itself; and why should we suppose that the brief notices of the great *physical* facts, connected with a *physical creation* and a *physical destruction*, are not correctly stated, in this earliest and most venerable of histories?

If all our discoveries regarding the surface and interior of the planet tend, when properly understood, to confirm the credibility of both these events, and to enable us to discriminate between the circumstances and evidence which belong to them respectively, what moral consideration can, in this case, forbid a happy application of the discoveries of science, and why should science refuse to lend its aid to the support of moral truth?

The question then recurs, how can the amount of time be found, consistently with the Mosaic history, for the order of the facts and of the history is the same. The solution of this difficulty has been attempted in the following modes.

1. *The present crust of the planet has been regularly formed between the first creation "in the beginning,"* and the commencement of the first day.*—It appears to be generally admitted by critics, that the period alluded to in the first verse of Genesis, "in the beginning," is not necessarily connected with the first day. It may therefore be regarded as standing by itself, and as it is not limited, it admits of any extension backward in time which the facts may require.†

Dr. Chalmers says: "Does Moses ever say, that when God created the heavens and the earth, he did more at the time alluded to than transform them out of previously existing materials? Or does he ever say, that there was not an interval of many ages betwixt the first act of creation, described in the first verse of the book of Genesis, and said to have been performed in the beginning, and those more detailed operations, the account of which commences at the second verse, and which are described to us as having been performed in so many days? Or, finally, does he ever make us understand, that the generations of man went further than to fix the antiquity of the species, and of consequence that they left the antiquity of the globe a free subject for the speculations of philosophers."—*Evid. Christ. Rev. in Ed. Encyc.*

By asserting that there was a beginning, it is declared that the world is not eternal, and the declaration that God made the heavens and the earth, is a bar equally against atheism and materialism. The world was, therefore, made *in time* by the omnipotent Creator.

The creation of the planet was no doubt instantaneous, as regards the materials, bnt the arrangement, at least of the crust, was gradual. As a subject either of moral or physical contemplation, we can say nothing better, than that it was the good pleasure of God not only that this world should be called into existence; but, that the arrangement by which it was to become a fit habitation for man, should be gradually progressive through many ages.

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* "*Of old* hast thou laid the foundations of the earth, and the heavens are the work of thy hands."—Ps. cii: 25. "And thou, Lord, *in the beginning*, hast laid the foundations of the earth."—Heb. i: 10.

† "This statement appears to be entirely distinct from all that follows."—*W. M. Higgins, F. G. S.; the Mosaic and Mineral Geologies: London*, 1833.

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This is in strict analogy with the regular course of things in the physical, moral and intellectual world. Every thing, except God, has a beginning, and every thing else is progressive. The human mind and our bodily powers, the growth of the animal and vegetable races, the seasons, seed time and harvest, science and arts, wealth, civilization, national power and character, and a thousand things more, evince that progression is stamped upon every thing, and that nothing reaches its perfection by a single leap. The gradual preparation of this planet for its ultimate destination, presents therefore no anomaly, and need not excite our surprise.

It is of no importance to us, whether our home was in a course of preparation during days or ages, for the moral dispensations of God towards our world could not begin until the creation of man.

The abyss of waters which existed before the emergence of the land, which preceded the creation of man, and continued for an unknown period of time, is just such a state of things, in coincidence with the operation of internal fire, as is demanded for the formation of the central rocks, and for their elevation, as far as facts may justify us in supposing that it took place before the formation of the derivative rocks, and of those containing organic remains.

The supposition now before us is equally consistent with both igneous and aqueous action; and indeed it would be impossible to account for the appearance of things without the conjoined agency of internal fire, and of an incumbent ocean; the latter repressing the expansive and explosive power of the former, causing its heat greatly to accumulate, even to the fusion of the most refractory materials; preventing the escape of gaseous matter, as for instance of carbonic acid gas from the limestones, and by its pressure and slow cooling, from the small conducting power of water, preventing melted rocks from assuming the appearance of volcanic cinders, slags, scoriæ, and other inflated masses.

The incumbent ocean is therefore indispensable, equally so with the agency of internal fire, to the correct deductions of the theoretical geologist.

With these views, then, the historical record happily agrees, and geology coincides with the sacred history.

During the period when this dark abyss of waters prevailed, the earth was without form, and void, or better, as Hebricians say—"the earth was invisible and unfurnished;" we may presume that then the early operations of geological formation and arrangement began, by producing the fundamental rocks, and thus providing materials for all the derivative strata, which, in the course of their consolidation, were destined to embosom such an endless diversity of extraneous contents.

This theory is satisfactory as far as it goes: it fairly recognizes and encounters the real difficulty in the case, and it would be quite sufficient to reconcile geology and the Mosaic history, as usually understood, did not the latter assign particular events to each of the successive periods called days; the most important of these events are, the first emergence of the mountains, and the creation of organized and living beings. It seems necessary therefore to embrace the days in the series of geological periods; and the difficulties of our subject will not be removed, unless we can show that there is time enough included in those periods called days, to cover the organic creation, and the formation of the rocks, in which the remains of these bodies are contained.

2. *The present crust was formed from the ruins and fragments of an earlier world, re-arranged and set in order during the six days of the creation.*—This explanation has been given by men of powerful minds, both theologians and geologists—men strongly impressed with the overwhelming evidence which the earth presents of innumerable events, and of progressive development through successive ages. It therefore honestly meets the difficulty, and fully grants the necessity of allowing sufficient time for the series of geological formations. This theory assigns the crystallization and consolidation of the primary rocks to a period of indefinite geological antiquity, and it also admits that they have undergone more recent modifications, particularly in being upheaved by subterranean force, which elevated not only themselves but the superincumbent strata.

The hypothesis has great merit, inasmuch as it admits, in the long gone-by ages, of just such events and successions as geology has proved to have taken place; but it demands general catastrophes, which do not appear to have happened, and it implies a recon-

struction of the crust of the planet entirely out of its own ruins, a supposition which is inconsistent with the state of facts. It is therefore unsatisfactory, because it does not provide at all for the regular successions of entombed animal and vegetable races, and for the progressive consolidation, often in long continued tranquillity, of the strata which are formed around the organic bodies, and also for the numerous alternations and repetitions of these strata, frequently, as in the coal fields, in a regular order. All this demands time, and seasons of protracted repose, interrupted indeed by occasional elevations, subsidences, and other violent movements. In order that this solution may prove satisfactory, it is necessary that the earth should really be what it actually is not, a confused pile of ruins, not only of loose fragments, such as are now found on its surface, but they must be consolidated, to form the mountains and the strata. Ruins, the mountains and strata do indeed in many places contain, but they form only a portion of a vast structure, in which ruins have no part.

The earth is unlike Memphis, Thebes, Persepolis, Babylon, Balbec or Palmyra, which present merely confused and mutilated masses of colossal and beautiful architecture, answering no purpose except to gratify curiosity, and to awaken a sublime and pathetic moral feeling; it is rather like modern Rome, replete indeed with the ruins of the ancient city, in part rearranged for purposes of utility and ornament, but also covered by the regular and perfect constructions of subsequent centuries.

The period is not far distant, when all thinking and reasonable men who make themselves acquainted with the structure of the earth, will come to the conclusion that the formation and arrangement of the crust, as we now see it, must have occupied many ages. This is already the conviction of all geologists, and of many who are not so by their pursuits; and nothing can prevent its becoming universal but ignorance of the facts, or a blind or perverse rejection of them in opposition equally to sound science and common sense. It is now generally admitted that the beginning was in remote antiquity, at a period whose date is unknown; and we are at liberty in consistency with sacred history to assume as much time anterior to the first day, as the events recorded in the structure of the earth may require. This appears at first

view to remove the difficulties, as they are supposed to exist between geology and revelation, and therefore this solution has been eagerly adopted by those who receive equally the truth of revelation as recorded in the Bible, and the truths of nature as registered in the earth. This extension of time may answer sufficiently for the primary rocks, and for those composed of fragments and ruins, so far as they do not contain organic remains or contain them accidentally. It is true, however, that among the fragmentary and brecciated rocks there are those that contain ruins charged with the remains of animals and plants; pieces of limestone, for example, enclosing corals, shells, or crinoidea, are found as parts of calcareous breccias, and in the same manner, plants embraced in argillaceous iron, or in slates and sandstones, may enter into the puddingstones and breccias, and it would be true of such rocks that they are formed from the ruins, if not of a previous world, at least of an earlier state of this world. But it must be observed, that by the supposition the organic remains now alluded to are not in the situation in which they were originally enclosed.

We will illustrate this by examples. Suppose a country occupied by the encrinal and coralline limestone. The rocks exhibit those beautiful forms either as they grew in the ocean, with all their exuberant and curious joints and branches standing upon their proper columns or stems and gently wrapped in the calcareous carbonate as it concreted around them; or perhaps they were fallen upon the floor of that early ocean, and their members perchance scattered around, but in the end they were equally enclosed in the delicate pabulum which was to preserve them without father alteration to distant ages.

Suppose also the fossils of the chalk formation—the echini with or without their spines, the alcyonia and sponges, the innumerable testacea, the vertebrated fishes, and, as we are now instructed, myriads of microscopic corallines and shell fish; let these and the other fossils of this chalk series be imagined as living in their native seas at the time when they were so exquisitely folded in their white chalky mantle as to insure the perfect preservation of their delicate forms, often with their minutest processes, spines, or other frail parts uninjured; still farther, let the flint, dissolved

perhaps in thermal alkaline waters, thrown up and issuing from the bottom of the chalk, now seek the organic forms and convert many of them into its own substance, but copying their organization so as to present silicified sponges, echini, alcyonia, &c.

Now these are instances of geological formations which, in such or in some other analogous modes, have certainly taken place, and innumerable repetitions of similar events have occurred from the time of the earliest organized beings down through successive ages, and are still going on. No one will however contend that these things are to be referred to the ruins of a former world; they are regular formations, and the animals and plants that may have been enclosed in the forming rocks have had no previous existence; where they are found petrified there they were born, and there they were interred in their stony tombs. Should any of these rocks, still retaining the enclosed organic bodies, be broken up into fragments, and should these fragments become united so as to form a breccia or conglomerate, this might with some propriety be called a formation from the ruins of a former world, or at least of an earlier stage of the present.

Regular and extensive formations, which enclose organized beings in immense numbers and in high preservation, must have demanded great time, prevailing tranquillity, and all the circumstances necessary both to sustain organic beings and to furnish the pabulum by which they were to be enclosed. The astonishing diversity of petrified and fossilized forms, found in strata of different kinds, of wide geographical extent, and in many instances of vast thickness, with their distinct and sometimes sudden alternations, successions, interventions and repetitions, demonstrate that physical laws of great energy reigned and produced their proper effects through vast periods of time.

It does not militate against the argument, that there were occasional convulsions, lacerating and dispersing in ruins portions of the fair fabrics that had been raised; or that less violent operations, carried on from age to age, tended more slowly but not less surely to the same result; the intercalated or concomitant processes of destruction served only to prove that there previously existed solid structures which the tooth of time or the crash of catastrophes had invaded, and therefore the regular mineral formations, the

entombed organized bodies, and the partial demolitions are thus linked into a harmonious system, furnishing a true geological chronometer and an authentic chronicle of physical events.

Now if the long range of time included between the beginning and the first day recorded in the Genesis is to cover not only the period in which those rocks were formed, that preceded the dawn of life, but also those that include organized beings and the formations composed of fragments, then it is obvious that the Mosaic history contains no notice of these events, *as belonging to that epoch.* But if it is still contended that the events really belonged to that period, although they are passed over in silence by the historian, and that six common days were allotted to rearrange and fit up the ruins of this ancient world, not only of rocks, but of animals and plants, so as to prepare the earth for the reception of the human race, then we feel justified in saying, that upon this supposition, the furniture of our present world could not possibly be what it now is, nor by any operation of physical laws could the arrangements be effected in so brief a period of time. The design would be most inappropriate, the appearances widely different from what we behold, and the work, except as a miracle, impossible. No supposition consistent alike with the work and the history will meet the exigencies of the case but a progress in the mineral formations coincident with the periods called days, in which life, in both organic kingdoms, is first announced in the Genesis, as the result of creative power.

Some eminent geologists, with whom reverence for the Scriptures and reverence for natural truth are only different modes of the same religious sentiment, both having for their basis veneration for the all-wise and benificent Creator, and proposing for their object, the promotion of confidence in him, and of obedience to his laws, have adopted this, as it appears to me, imperfect, if not inconsistent solution of the geological difficulties. As regards the coincidence of mineral formations with organic beings, it is just such a solution as would be satisfactory, were there no divisions of time in the Mosaic narrative, and nothing more announced in it than the order of events as actually narrated, the whole range between *the beginning* and the creation of man being left unembarrassed by the limitation of days, and perfectly free to be appropri-

ated in ample eras, as the events may seem to require. As the earth is really constituted, it will however answer no valuable purpose to imagine the collected ruins of a former world, brought together, to be remodelled; as the mariner who has survived the tempest, refits, with broken spars and sails, his wrecked and ruined ship. If the ruins and fragments of the present world are to be regarded as mere materials which are again to be concocted; in part dissolved or melted, and elaborately and skilfully wought over anew, to produce our present world, then this is equivalent to a new creation, and thus we introduce a double operation by almighty power, when one is quite sufficient, and after all, we leave our difficulties where we found them, without solution and without mitigation. This we must conclude is far from the truth, and our convictions are confirmed by surveying, with Mr. Lyell, the causes that are still in full operation, the geological events that are now in progress, and the effects that are proceeding without impediment or delay, and we thus discover, that since the creation, as regards geological causes, except their varying if not diminished intensity of action, all things remain as they were; no new code of physical laws has been enacted; while the beginning was with God, the continuation of events is with us, and a distant posterity may not witness their termination.

3. *It has been supposed that the succession of geological events may have happened in the first ages of the world, after the creation of man, and before the general deluge.*—This supposition is wholly irreconcilable with facts. The universal prevalence of the waters, rendered it indispensable that the first geological movement should elevate some portion of the land above the ocean. The great series of geological events by which the continents and islands were raised, was incompatible with the residence of man upon the earth: they precluded even the existence of terrestrial quadrupeds, which both geology and the scripture history assign to a late period in the order of things, the same period in the close of which man himself first appears; these movements were, until the period immediately preceding, hostile to the welfare of any beings that required more land than amphibious reptiles; and the vast deposits of fossilized and of crystallized rocks that preceded the era of reptiles, demanded an alternate and con-

comitant prevalence of water on the surface, and of fire beneath, which were ill adapted to produce and insure the quiet and firm state of the surface, such as we see it now. Although the great agents are still in operation, fire, water, storms, volcanoes, earthquakes, &c., their ultimate effects, if not mitigated in force, are spread through such a range of time, that human life is too limited to cover an extensive cycle of geological changes; the entire period since man was created is, in comparison with geological eras, but a brief space, and does not begin to bear any proportion to eternity. We have therefore, no reason to suppose that the earth has undergone any such changes, as to affect materially the integrity of its entire crust, since man appeared in the world.

It is true that events are in progress by which a series of fragmentary and fossilized if not of crystallized rocks is forming anew, and they may in time be elevated above the waters of the existing seas, while fresh-water deposits may in turn be drained; this world may last so long, that new continents may arise, where there is now a wild waste of waters, and far more ample space of redeemed land may be provided for the human family, without materially abridging the great highway of nations over the seas. There is no intimation in Sacred History, that any such events happened between the creation and the deluge, and it is obvious that the sparse population of the antediluvian world did not require more territory, especially when the existing races, with the exception of a few individuals, were soon to be consigned to the bosom of the deep, and all the continents and islands when again redeemed from water, were about to be given, in full dominion, to a single family. Although but one fourth part of the land of our world is, to this hour, reclaimed from the ocean, the population of the human family is far from occupying it all. Few countries are as yet peopled to the extent of their means of support, and it will require ages of peace and pure morals and effective industry, before more room will be demanded. We cannot therefore suppose, that a new continent would be elevated, until there should be a necessity for its appearance, and as nothing in sacred or profane history or in the structure of the earth intimates that such an event has happened, we feel quite certain that the great geological arrangements were accomplished before the human era.

4. *It has been supposed that a general deluge will account for all geological events.*—In the progress of the preceding remarks we have already had occasion to express a decided opinion on this subject, and it now remains only to sum up the argument.

This view is entirely inadmissible, except as to those superficial ruins which are commonly spoken of as diluvial. In using this term, geologists do not intend to imply, that these ruins are, of course, attributable to the deluge of the Scriptures.

In geology, a deluge is a rise and overflow of water. It has no exact limit in time, altitude or violence. A rain, a snow thaw, an outburst of a lake, a tide, a gale, or a whirlwind, may produce an overflow, but it is not usual to call the event a deluge unless the elevation has been both sudden and considerable. Were the barrier which forms the falls of Niagara to be suddenly ruptured, Lower Canada, New England and New York would be deluged; but the remarkable accumulation of water in the late seasons in the great lakes, in consequence of which they overflowed many buildings and many square miles of territory was not called a deluge.

The facts revealed by geology demand many partial deluges, and they are admitted by all geologists, with greater or less extent, to account for the transport and deposition of those things which water alone, or water aided by ice could convey. It is necessary also to suppose, that both fresh and salt water, either by their rising or by the subsidence of land, have alternately prevailed and retired, after continuing an indefinite period; sufficiently long, however, to give time for the various animals and plants, marine, littoral, pelagian, fluviatile, or lacustrine, which we find in successive strata, to be deposited and entombed. Igneous action, giving rise, in its vicissitudes, to subterranean expansion and shrinking, heaving and collapses, was the probable cause of these alternate movements.

Our concern, however, in the discussion under this head, is not with those regular formations which demand long continued energy of physical powers, and corresponding time to produce the effects; but it is with the general deluge, described in the book of Genesis, because we are writing for the sake of those who believe in the genuineness and authenticity of that history.

From the whole course of our argument, it is obvious, that the regular geological formations cannot be ascribed to that short and transient catastrophe. Its genuine effects are exactly those which all geologists ascribe to diluvial action; namely, the transportation of the loose ruins of mineral masses, and of the organic world, which are found strewed every where over the surface of the earth, or buried in its diluvium.

Professor Buckland, in his Reliquiæ Diluvianæ, has most ably illustrated the nature and effects of diluvial action; and it is obvious, that the former practice of attributing the organized remains found in the solid strata of the earth to this catastrophe, is founded entirely in an imperfect acquaintance with the subject, and that no man, who had studied geology thoroughly, would, at the present period, fall into such an error.

As the impression has gone abroad that Professor Buckland has deserted the opinions which he formerly maintained, we give him an opportunity to speak for himself. "The evidence (says he) which I have collected in my Reliquiæ Diluvianæ, 1823, shows, that one of the last great physical events that have effected the surface of our globe was a violent inundation, which overwhelmed a great part of the northern hemisphere, and that this event was followed by the sudden disappearance of a large number of the species of terrestrial quadrupeds which had inhabited these regions in the period immediately preceding it. I also ventured to apply the name *Diluvial*, to the superficial beds of gravel, clay and sand, which appear to have been produced by this great irruption of water.

"The description of the facts that form the evidence presented in this volume, is kept distinct from the question of the identity of the event attested by them with any deluge recorded in history. Discoveries which have been made since the publication of this work, show, that many of the animals therein described, existed during more than one geological period preceding the catastrophe by which they were extirpated. Hence it seems more probable that the event in question was the last of the many geological revolutions that have been produced by violent irruptions of water, rather than the comparatively tranquil inundation described in the inspired narrative.

"It has been justly argued, against the attempt to identify these two great historical and natural phenomena, that as the rise and fall of the waters of the Mosaic deluge are described to have been gradual and of short duration, they would have produced comparatively little change on the surface of the country they overflowed. The large preponderance of extinct species among the animals we find in caves, and in superficial deposits of diluvium, and the non-discovery of human bones along with them, afford other strong reasons for referring these species to a period anterior to the creation of man. This important point, however, cannot be considered as completely settled, till more detailed investigations of the newest members of the Pliocene, and of the diluvial and alluvial formations, shall have taken place."*

It appears then, that there is no other change in Prof. Buckland's views than what is common to the geological world, viz. that amidst the vast exuberance of diluvial remains, it is impossible to appropriate to the general deluge, those that belong to it, rather than to more local debacles, and to those of a different era.

It is not to be supposed that all deposits of gravel, sand, pebbles, &c. are attributable to the deluge of the Scriptures, for it is beyond our power to identify the particular piles and scattered ruins. It is sufficient to say, that as the earth bears every where, marks of diluvial action, and is in every country strewed with diluvial ruins, each observer will, for himself, assign to local deluges, or to a general debacle, as great a portion of the effects as may in his view belong to each. Scepticism cannot nullify or set aside the evidence, while the most reverent mind need not desire it to be more ample, nor is he who attributes diluvial remains, in many instances, to other diluvial events, to be censured, or regarded as an enemy to religious truth.

To those who would assign to the agency of a general deluge the vast work of depositing the immense consolidated geological formations, with all their varied stores of animals, and plants, and fragments, and diversified successions, we can only repeat the opinion already expressed, that such effects, from such a cause,

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* Bridgewater Treatise, 2d Lond. edit., p. 93, note.

are physically impossible, especially within the limits of time and under the circumstances assigned in the Mosaic account. It is not necessary to go again into the induction of particulars.

We are however still of the opinion, that the actual disposition and arrangement of no small portion of the loose materials is to be attributed mainly to a diluvial ocean—no other probable cause being capable of reaching the regions remote from, and elevated above the present great waters of the globe, while the outline, and in many instances the mass of these deposits, must have been often disturbed by subsequent events.

The arrangement of the loose materials, on shores and in outlets, and in regions occasionally flooded, is to be referred to agencies now in operation.

It is also true, that water-worn pebbles are produced at the present time. No one who, on the sea shore, has observed the incessant lashing of the waves, and has listened to the hollow hum of the stones and pebbles rubbing against each other, with ceaseless friction, can doubt, that rounded, water-worn pebbles, are now every moment forming ; and were they found no where else, except on the shores, and in moving waters, there would generally be no difficulty in assigning their origin to this cause. But rounded stones, water-worn pebbles, and bowlders, are found in every country, on the surface and in the soil, and in regions the most remote from the ocean. This of course proves the universal prevalence, sooner or later, at once or successively, of agitated waters.

Why not, says an inquirer, attribute the rounding, as well as the position of the inland water-worn stones to the *diluvial* ocean ? The obvious answer is, that the time allotted to the deluge described in Genesis is too short for the process of grinding down hard stones, which would necessarily occupy a very long period. A deluge attended by rapid currents and by floating ice could transport immense masses of these ruins, and deposit them where, to a great extent, we now find them ; but it was not possible that it could, in so limited a period, have effected much, in abrading the angular fragments of quartz, topaz,* and other hard stones,

* Found on a beach in New Holland. We have a topaz pebble from these shores which is perfectly ovoidal.

into ovoidal and globular pebbles and bowlders. That effect appears to have been, principally, the work of the earlier oceans.

The form of the loose materials that cover the rocks, more or less, in every country, is attributable chiefly to the wearing effects of agents, operating, *in all time*, to produce disintegration and decomposition; their present position may, in many cases, be fairly attributed to diluvial agency.

An ingenious author, Mr. Penn, convinced that the deluge could not account for the geological successions, has supposed them to be formed in the ocean, between the creation of man and the deluge, at which time the then existing land was, as he thinks, sunk, and the bed of the ocean raised, to form our present continents, bringing up, of course, all the marine deposits of sixteen centuries.

It is not necessary to discuss this theory. It is disproved by the discovery in caverns, and in the loose wreck, on the surface of the ground, of immense deposits of the bones of terrestrial animals, which have not, within the limits of human knowledge, lived in those countries where they are now found, and many of which could not exist in the present climates of those regions; for instance, the tropical animals, elephants, tigers, hyenas, hippopotami, rhinoceros, &c., are found now abundantly in the diluvium of England, and consequently England was dry land before the deluge that buried these remains, and therefore the existing continents have not been raised from the ocean since the creation of terrestrial quadrupeds, unless they were submersed after that epoch and then raised again. Of this there is not only no proof but the opposite is proved, because the diluvium is not covered by marine strata. Nor is it possible that the drowned quadrupeds of tropical regions should, by drifting, have reached England, and other countries still farther north, without decomposition and falling to pieces.

The coal beds also present indubitable proofs of having been formed from terrestrial vegetables, and therefore the regions where they are could not have been submarine, although the occurrence in coal-fields of some marine shells or plants may prove, that at the coal period there were islands and estuaries, where the sea had at least occasional access. Had the continents been again submersed and the bottom of the sea raised, after the creation of man,

we should find in the surface of the present crust, nothing but marine remains, which is contrary to the fact.

The existence of scratches and furrows* upon many rocks, (probably upon all when the diluvium is first removed from them,) appears to prove, that they have been subjected to movements of heavy bodies passing over them, either rolling down inclined surfaces, or forced along by floods, or pushed by glaciers, or dragged by moving ice, in which stones and rocks are very often frozen. The direction of these scratches on this continent, as well as in Europe, is such as to give the idea of a current or irruption from the north.

If the general deluge were a gentle movement, as Dr. Buckland now supposes, it could, as he justly observes, have produced very little alteration on the surface of the earth. If violent and rapid, then the effects would not have been forming, but destroying.

This is not the place to discuss the question of its literal universality. Many theologians have supposed that it was no farther universal than to accomplish its great object, the destruction of the existing races, except the reserved few. If it were strictly universal, and the highest mountains now known were literally covered to a considerable depth, it will be found that its rise must have been fearfully rapid, far transcending the most violent tides and bores with which we are acquainted, and that it would then be well adapted to harrow up the surface of the ground, and to transport and disperse its ruins, far and wide, over distant countries.

Upon either view, however, the deluge could never have produced the regular formations of the crust of the earth, and therefore, as regards this question, we may dismiss it from our contemplations.

We conclude this head by observing, that the remains of the human family, if buried in the diluvium of that period, may, in most instances, have been covered too deep for discovery, or have been swept into the sea; or if found in any instances, it is not probable that they would be distinguished from

* See an interesting paper by Mr. T. A. Conrad on the subject of the transfer of bowlders, &c. in the Am. Jour., Vol. xxxv, p. 237. Also an admirable memoir by Prof. Agassiz on glaciers, moraines, and erratic blocks.—*Jameson's Edinb. Jour.*, Vol. xxiv, p. 364.

bones buried in any other way, especially in countries like those which were then the principal seats of the human population; countries in which there has been since, no enlightened curiosity to prompt an intelligent research. We are not, at present, concerned to remove sceptical objections to the Scripture account of the deluge; we take it for granted that it is true, but the friends of the Bible sometimes suggest a question with respect to the inhumed human bones of that period, and this difficulty we wish to remove.

5. *The divisions of time called days in the Genesis are not necessarily restricted to twenty four hours, but may be understood to be periods of indefinite length.*—This view was supported, a few years since, by that eminent geologist, Professor Jameson, of the University of Edinburgh, in a comment upon the lectures of the illustrious Cuvier. We quoted the observations of Prof. Jameson,* in discussing the subject, in connexion with our edition of Mr. Bakewell's Geology, in 1833, and we shall make use of some of them on the present occasion. Cuvier remarks:—

"The books of Moses show us, that he had very perfect ideas respecting several of the highest questions of natural philosophy. His cosmogony especially, considered in a purely scientific view, is extremely remarkable, inasmuch as the order which it assigns to the different epochs of creation, is precisely the same as that which has been deduced from geological considerations."

"This, then, is the issue, in the opinion of Baron Cuvier, of that science, which has been held by many persons to teach conclusions at variance with the Book of Genesis,—when at last more matured by a series of careful observations and legitimate induction, it teaches us precisely what Moses had taught more than three thousand years ago."

We have already remarked, that the coincidences in the Mosaic account of the creation with the truths of geology, are the more valuable, because they are merely incidental to the main object of the history, which was to show that the world had a beginning, and was not eternal, to vindicate the claims of the Creator, as its author and governor, to point out the original state of the globe, and its progress towards a habitable condition, by the emergence

* Am. Jour. Vol. xxv, p. 26.

of the land,—to indicate the commencement of life, the order which the principal classes of animated beings first appeared, a the final redemption of so much of it from the waters as w necessary to prepare it for man, whose creation consummat these astonishing displays of almighty power. Perhaps the clai to a perfect coincidence between geology and the sacred histo have been sometimes made in terms rather too unqualified. is sufficient that there is a perfect coincidence in the great poin and inconsistency in nothing. A want of agreement has be stated as regards the priority of the animals of the transiti rocks, in as much as they are found in deeper strata than the veg tation of the great coal period, whereas the vegetables are fi named in the Mosaic account, and the earliest fossilized anima actually found, are not mentioned at all. In regard to the vege bles, there is good reason to believe that they were at least early as any animals; vegetables are found, more or less, throu the whole transition series, in which the trilobites, orthoceræ, e crinites, corallines and mollusca, first appear; and we may p bably regard plumbago as the result of vegetable matter, so p fectly carbonized as to have entirely expelled all the gases, and have destroyed the traces of vegetable structure,—an opini which is entertained by many geologists. Upon this view, veg tables will take the highest rank in organic antiquity, since plu bago, and even anthracite, are found in some of the slaty rocks the granite family, anterior to the first appearance of any anima

With respect to the silence of the history as to the very fi animals, it may be said, that a brief narrative concerning the st pendous work of the creation, comprised within the limits of single page, could not be expected to contain the minute deta of natural history, and less important families would therefo naturally be omitted. Where in the history, is there menti made of infusorial animalculæ, any more than of the animals the transition rocks? But as we cannot dispute the existence these beings, both fossil and recent, there can be no doubt th their originals were really created. If in every other particula this surprising history is consistent almost with the letter of t facts, and for so general a sketch, remarkably complete, it ma well excite our admiration and gratitude. Professor Jamesc proceeds:—

"The first chapter of Genesis is written in a pure Hebrew. This was the language spoken, and afterwards extensively written, by the people whom Moses conducted to Palestine from the land of Goshen. That it differed greatly from the language of the Egyptians, we have full proof in the Coptic remains of the latter, in the Egyptian proper names preserved in the Hebrew writings, and also in the circumstance that Joseph, when pretending to be an Egyptian, conversed with his brethren by means of an interpreter. Yet in the chapter in question, we find no foreign terms, no appearance of its being translated from any other tongue; but, on the contrary, it bears every internal mark of being purely original, for the style is condensed and idiomatical in the very highest degree. Had Moses derived his science from Egypt, either by oral communication or the study of Egyptian writings, it is inconceivable that some of his terms, or the style of his composition, should not, in some point or other, betray the plagiary or copyist.

"But the conjecture that Moses borrowed his cosmogony from the Egytians, must rest, moreover, on a supposition that the order which he assigns for the different epochs of creation, had been determined by a course of observation and induction, and the correct application of many other highly perfected sciences to the illustration of the subject, equal at least in their accuracy and philosophical precision, to those by which our present geological knowledge has been obtained. Nothing less than this can account for Moses' teaching us precisely what the modern geology teaches, if we allow his knowledge to be merely human. How comes it to pass, then, that while he has given us the perfect and satisfactory results, he has been enabled so totally to exclude from his record every trace of the steps by which they were obtained? The supposition of such perfection of geological knowledge in ancient Egypt, implies a long series of observation by many individuals, having the same object in view. It implies of necessity, also, the invention and use of many defined terms of science, without which there could have been no mutual understanding among the different observers, and of course no progress in their pursuit. These terms have all totally disappeared in the hands of Moses. He translated, with precision, the whole science of geology into

the language of shepherds and husbandmen, leaving no trace whatever of any one of its peculiar terms, any more than of the curious steps in its progress.

"But there is a phenomenon in his record still more unaccountable, upon any supposition that his science is merely human. His geology, acknowledged by the highest authority in this age of scientific improvement, to be thus accurate, dwindles down in his hands to be a merely incidental appendage of the most rational and sublime theology. This latter he did not learn in Egypt, for it was in the possession of his ancestors while they were yet inhabitants of Canaan.

"Shall we then conjecture, that Moses borrowed theology from the Hebrews on the one hand, and geological science from the Egyptians on the other, to compound out of them that brief, but unique and perfect system of both, which is presented to us in the first chapter of Genesis; or, is it possible that we could adopt any conjecture more absurd, and this, too, in utter destitution of all proof that the Egyptians possessed any knowledge of geology in the sense in which we use the term?

"The result of our inquiry is, that the geology of Moses has come down to us out of a period of remote antiquity, before the light of human science arose; for, to suppose that it was borrowed from, or possessed by any other people than the remarkable race to which Moses himself belonged, involves us, on all hands, in the most inextricable difficulties and palpable absurdities. Of that race, it has been long since justly remarked, that while in religion they were men, in human learning and science they were children; and if we find in their records any perfect system of an extensive and difficult science, we know they have not obtained it by the regular processes of observation and induction, which in the hands of European philosophers, have led to a high degree of perfection in many sciences."

Professor Jameson proceeds to remark:—

"The term, the meaning of which we shall first investigate, is '*day*' (in the Hebrew, yom.) The interpretation of this, in the sense '*epoch*' or '*period*,' has been a subject of animadversion, of unnecessary severity in some cases. A careful examination of the first chapter of Genesis itself, leads unavoidably to the con-

clusion, that our natural day of one revolution of the sun cannot be meant by it, for we find that no fewer than three of the six days had passed before the measure of our present day was established. It was only on the fourth day, or epoch of the creation, that "God made two great lights to divide the day from the night, and to be for signs, and for seasons, and for days, and for years.' The very first time that the term occurs in the Hebrew text, after the history of the six days' work, and of the rest of the seventh, as if to furnish us with definite information regarding its true import, we find it employed in a similar manner to that in which we must understand it here; for, in Gen. ii, 4, we have, 'These are the generations of the heavens and the earth, *in the day* (beyom) that the Lord God made the earth and heavens.' The use of the term in this indefinite sense is so common in the Hebrew writings, that it would be a great labor to quote all the passages in which it is found; and we shall satisfy ourselves by at present referring to Job xviii, 20, where it is put for the whole period of a man's life, 'They that come after him shall be astonished at *his day*,' (yomu,) speaking of the life of the wicked; and Isaiah xxx, 8, where it is put for all future time, 'Now go note it in a book, that it may be for the latter *day* (leyom) for ever and ever.'"

We will here cite the following passages to the same intent.

Luke xvii, 24.—So also shall the son of man be in his *day*.

John viii, 56.—Your father, Abraham, rejoiced to see my day; and he saw it and was glad.

2 Peter iii, 8.—One day is with the Lord as a thousand years, and a thousand years as one day.

Job xiv, 6.—Turn from him, that he may rest till he shall accomplish as an hireling his day.

Ezekiel xxi, 25.—And thou profane wicked prince of Israel, whose day is come, when iniquity shall have an end.

Proverbs vi, 34.—For jealousy is the rage of a man; therefore he will not spare in the day of vengeance.

"It is quite obvious, from these examples, that the Hebrews used the term (yom) to express long periods of time. The very conditions of the history in this chapter, prove that it must be here so understood."

"They who object to this interpretation of the term here, immediately quote against it the reason added to the fourth commandment, 'For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested the seventh day, wherefore the Lord blessed the Sabbath-day and sanctified it.' This is, however, no more than a brief reference, and the terms of it must therefore be strictly interpreted in accordance with those of the detail to which the reference is made."*

"It has been said that such an interpretation goes to nullify the reasons assigned for the sanctification of every seventh revolution of the sun; but this does not follow. In point of fact, the rest from the work of creation (we use this form of speech from the example before us) did not endure for only one revolution of the sun, but has continued since the creation of man; and we have no grounds on which to establish even a conjecture of the time of its coming to a close; so that if we were urged to adopt a period of twenty four hours as the meaning of yom, that the six days of creation might literally correspond with our six working days, we should then find the apparent disagreement, which, by this process, we would endeavor to avoid, transferred to our weekly period of rest, and the rest from the work of creation."

"It will surely be readily allowed, that the sanctification of the Sabbath has respect to man and his duties; and since his Creator has been made known to him, and the order of the six successive epochs in which the earth was rendered fit for his habitation; if we are to allow, what surely no reflecting mind will ever deny, that it is his duty to reflect with gratitude on the blessing he has received, and to maintain in his heart a sense of his dependence upon, and responsibility to him, who made the heavens and the earth, and all that they contain, no method could have been devised better calculated for preserving these feelings in constant activity, than appointing some definite portion of time, returning at short intervals, to be devoted to the contemplations that awaken them, nor any interval more appropriate than that which so directly recalls the order of the events of the creation."

* In accordance also with the popular acceptation of the length of the days of the creation, to which the allusions in the Scriptures are, every where, necessarily accommodated.

"Since we have introduced the subject of the measure of our present day, we would offer an observation regarding the work of the fourth day, which includes the sun, moon and stars. Respecting the period of their creation, geology, from its nature, gives us no precisely definite indications. The history regarding them is from the 14th to the 18th verses, and we would observe of it, that the terms employed are such as do not absolutely imply that these bodies were at this epoch first created, but admit of the interpretation that their motions were then first made the measures of our present days and seasons. We had found it already stated in the first verse, that the heavens and the earth were created *in the beginning*, antecedently to the work of six days, by which they were reduced to their present order, and the earth was peopled with organized beings. It would seem an unwarrantable interpretation to exclude the sun, moon and stars from among the objects expressed by the general terms, the heavens and the earth. It is the most obvious interpretation, that they were then created, and were lighted up on the first day, but that it was only during the fourth epoch they were made, the greater light to rule over the present day, and the lesser light to rule over the present night, and to be for signs, and for seasons, and for days and years, according to the measures of time, which we now find established by them. This part of the history, then, when interpreted in consistency with the first verse, and without any violence to the terms, implies, (in the common language of men, which, in all nations, refers the diurnal and annual revolutions of the heavenly bodies to the motions of these bodies themselves,) that the earth was, during this epoch, finally brought into its present orbit."

"The work of the third epoch was the appearance of the dry land, and the creation of the vegetable kingdom."

In following Professor Jameson, we shall here omit his critical remarks on the meaning of the Hebrew words in the original history, of the correctness of which Hebrew scholars will judge, and proceed at once to his conclusion, which is that it is very probable the cryptogamous vegetation was the first created; and this corresponds sufficiently well with the prevailing character of the earliest plants. This is a remarkable epoch, when the waters

were gathered together into one place, and the dry land began to appear; or, in geological language, the first mountain top raised its crest above the waters of that shoreless ocean. Before this period, there could have been no terrestrial plants, for there was neither soil nor fixture. Internal fire, doubtless, lifted the emerging islands and continents, while the desolation of the universal waters began to be cheered by the verdure of plants, the beauty of flowers, and the fragrance of fruits. Not far from this period also, as we learn from their fossilized remains, were created those early animals, which being entirely immersed in the ocean, and destined never to raise themselves above its surface, made no figure in the drama of creation, and are therefore passed over in silence in the brief roll-call of beings that were first called into life. In proceeding to those animals which are next announced, our author arrives at some important conclusions that appear worthy of great confidence. Omitting his criticisms, as before, we give the results.

The creations of the fifth epoch are evidently not great whales, as usually understood, but great reptiles; and the entire work of the fifth day appears to have included things that rapidly multiplied in the waters, great reptiles, birds, and winged insects. This corresponds wonderfully with the contents of the rocks* belonging to this period, the animals being altogether oviparous, and none of them viviparous.

Lastly, in the sixth period, the terrestrial animals, mammalia and man, are called into being, and we know how well this agrees with the contents of the upper strata, where alone (with a solitary exception) viviparous animals are found, and man no where except at the surface. The following table of geological coincidences, drawn up by Professor Jameson, may need a few additions and alterations to accommodate it to more recent observations, but is still mainly correct.

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* In our remarks upon the successive rock formations, we have purposely omitted any allusion to the metamorphic theory espoused by the Huttonian school, ably illustrated by Mr. Lyell, and carried to an incredible extreme by Prof. Keilhau in his account of the rocks around Christiana, Norway, where, according to him, granite passes, by insensible gradations, into slates replete with organic remains. His observations are very curious, and many of them original, but they will demand a very strict revision.—*See Jameson's Edinb. Jour. Vol. 25, pp.* 80—203.

Table of Coincidences between the Order of Events as described in Genesis, and that unfolded by Geological Investigation.

In Genesis.	No.	*Discovered by Geology.*
Gen. I. 1, 2. In the beginning God created the heavens and the earth. And the earth was without form and void; and darkness was upon the face of the deep; and the Spirit of God moved upon the face of the waters.	1	It is impossible to deny, that the waters of the sea have formerly, and for a long time, covered those masses of matter which now constitute our highest mountains;
3, 4, 5. *Creation of light.* 6, 7, 8. *Creation of the expansion or atmosphere.* 9, 10. Appearance of the dry land.	2	and, further, that these waters, during a long time, did not support any living bodies.—*Cuvier's Theory of the Earth, sect.* 7.
11, 12, 13. Creation of shooting plants, and of seed-bearing herbs and trees.	3	1. Cryptogamous plants in the coal strata.*—*Many observers.* 2. Species of the most perfect developed class, the Dicotyledonous, already appear in the period of the secondary formations, and the first traces of them can be shown in the oldest strata of the secondary formation; while they uninterruptedly increase in the successive formations.—*Prof. Jameson's remarks on the Ancient Flora of the Earth.*
14 to 19. *Sun, moon and stars made to be for signs, and for seasons, and for days, and for years.*		
20. Creation of the inhabitants of the waters.	4	Shells† in Alpine and Jura limestone.—*Humboldt's tables.* Fish in Jura limestone.—*Do.* Teeth and scales of fish in Tilgate sandstone.—*Dr. Mantell.*
Creation of flying things.	5	Bones of birds in Tilgate sandstone.—*Dr. Mantell, Geological Transactions*, 1826. Elytra (sheaths) of winged insects in calcareous slate at Stonesfield.—*Dr. Mantell.*
21. The creation of great reptiles.	6	It will be impossible not to acknowledge as a certain truth, the number, the largeness, and the variety of the reptiles, which inhabited the seas or the land at the epoch in which the strata of Jura were deposited.—*Cuvier's Ossem. Foss.* There was a period when the earth was peopled by oviparous quadrupeds of the most appalling magnitude. Reptiles were the lords of creation.—*Dr. Mantell.*

* It would appear that the earliest animals not named by Moses were cotemporary with, perhaps subsequent to, the first plants.—Ed.

† Shells are found also in the earliest periods in the transition; the Jura limestone is coeval with the chalk formation. Fish are found below the coal, and in the transition rocks. Tracks of birds and reptiles in new red sandstone, in Connecticut and Germany.—Ed.

In Genesis.	No.	*Discovered by Geology.*
24, 25. Creation of the mammalia.	7	Bones of mammiferous land quadrupeds,* found only when we come up to the formations above the coarse limestone, which is above the chalk.†—*Cuvier's Theory, sect.* 20.
26, 27. Creation of man.	8	No human remains among extraneous fossils.—*Cuvier's Theory, sect.* 32. But found covered with mud in caves‡ of Bize.—*Journal.*
Genesis, VII. The flood of Noah, 4200 years ago.	9	The crust of the globe has been subjected to a great and sudden revolution, which cannot be dated much farther back than five or six thousand years ago.—*Cuvier's Theory*, 32, 33, 34, 35, *and Buckland's Reliq. Dilus.*

The following remarks in illustration of this table as a summary of the subject, are too interesting to be omitted.

"In the above table we have not taken advantage of the distinction, which we conceive we have gone far to prove is expressed in the Hebrew text, between the cryptogamous and the other classes of plants, but have set downt he whole vegetable kingdom as forming only one element in the table. We shall also allow that the 4th, 5th, and 6th numbers may be liable to be interchanged among themselves in respect of place, and shall hinge no argument upon them farther than what arises from the circumstance that they are all placed in one group. Yet, after these abatements from the number of particulars, the coincidences here shown between the order of the epochs of creation assigned in Genesis, and that discovered by geology, are calculated to excite the deepest attention. Human science, in the probability of

* It has been objected to the geological account of the death of animals found in the rocks, that as death came into the world by sin, there could have been no death until after the fall of Adam. Most evidently the death referred to is the spiritual death of the human race; we do not object to its being explained so as to include also their physical death, but plainly it has no reference whatever to the death of animals. The carnivorous regimen established among particular genera of all the classes of animals, sufficiently proves that the death of some was indispensable to the continuance of others in life; and Dr. Buckland has shown that it is on the whole a dispensation of mercy, as the amount of animal enjoyment is thereby much increased as well as by their natural death; otherwise the world would be overrun with aged and infirm races and individuals.—Ed.

† One solitary exception is since discovered in the calcareous slate of Stonesfield, in the bones of a didelphis, an opossum, belonging to a tribe of animals whose position may be held to be intermediate between the oviparous and mammiferous races.

‡ And in Guadaloupe and Brazil, in a recent concretionary limestone.—Ed.

chances, as illustrated by La Place, has put us in possession of an instrument for estimating their value; and we feel amply entitled to take advantage of it for that purpose, for no case could well be pointed out where it would be more correctly applicable than in this, where the coincidences assume a definitely successive numerical form. We are entitled to adopt even the very language of La Place, and to say, 'By subjecting the probability of these coincidences to computation, it is found that there is more than sixty thousand to one against the hypothesis that they are the effect of chance.'*

"It is thus then that the discoveries of geology, when more matured, instead of throwing suspicion on the truths of revelation, as the first steps in them led some persons to maintain, have furnished the most overpowering evidence in behalf of one branch of these truths. The result of these discoveries has been in this respect similar to those of the Chinese and Egyptian histories and the Indian astronomy, but much more striking. Eminent men had pledged their fame in setting up these histories, and that astronomy, in opposition to the chronology of Genesis; but farther and more careful inquiry into their true characters, discovered, that when rightly understood, they only tended to confirm it."

"We are not afraid that we shall have here quoted against us the words of Bacon, 'Tanto magis hæc vanitas inhibenda venit, et coercenda, quia ex divinorum et humanorum, male sana admixtione, non solum educitur, philosophia phantastica, sed etiam religio hæretica.' We have only endeavored to illustrate and point out the consequences of the statement of Baron Cuvier, 'that the order which the cosmogony of Moses assigns to the different epochs of creation, is precisely the same as that which has been deduced from geological considerations.' We have been guilty of no improper mixing up of divine and human things. We have examined the meaning of the terms in the first chapter of Genesis, in consistency with the acknowledged rules of criticism, and only by the light contained within itself, or that thrown upon it by the other books in the same language with which it is associated. The human science we have not extracted from any part of the Holy Scriptures; we

* Syst. du Monde, book v, chap. 5.

have taken it simply as we find it in the works of eminent geologists. As the latter is not a philosophia phantastica, but a deeply interesting science, constructed by that method of careful observation and cautious induction, which Bacon was himself the first to recommend; so neither can the sense of the Scriptures present to us a religio hæretica. If our science, thus constructed, and our religion speak so obviously the same language, as we see they do on one important point, what else in the strictest application of Bacon's philosophy, can we deduce from the circumstance, but that both are certainly true?"

"It does not come under our present subject to discuss the historical and moral evidences of the divine revelation of the Scriptures; but both are so full, even to overflowing, and impose upon us so many insuperable difficulties in the way of our being able to account for the quality and consistency of these remarkable books, excepting on the ground which has been all along assumed by themselves, that they are of more than human origin, that in estimating the accuracy of any part of the matters contained in them, the fastidiousness of human science appears to be carried to an unreasonable extent, not to take these evidences into calculation. In this country,* where for a long period we have had the Scriptures in our hands as a popular book, they among us who have been the most eminent for human learning and science, and whose fame has been in every view the most unsullied, have been so convinced by the force of these evidences, that they have in general been the most strenuous defenders of revelation."

"Will not human science, then, condescend to borrow some light to direct the steps of its own inquiries, from a record the accuracy of which it has itself proved, and which is supported by other proofs of the highest order? Or,† what should we say to the illustrator of the relics of Pompeii and Herculaneum, who should reject the light thrown on them by the letters of Pliny, authenticated as these are by the existing remains of the buried cities, as well as the historical evidence which is proper to themselves."

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* Scotland, but the author's remark applies with equal force in this country.—Ed.

† This argument we attempted to illustrate in the early part of the present discussion.—Ed.

RECAPITULATION.

The opinions of Professor Jameson illustrating the views of the lamented Cuvier, being those that are satisfactory to ourselves, we have quoted them with few omissions.

We now proceed to remark, that we are aware, from much communication on this subject with eminent biblical critics and divines, how tenacious they are, in common with the less enlightened Christian world, of the common acceptation of the word day. On points of verbal criticism we will not presume to speak with great confidence, but from much consideration, aided by the light both of criticism and geology, it does not appear to us necessary to limit the word day, in this account, to the period of twenty four hours.

1. This word could have no definite application before the present measure of a day and night was established by the instituted revolution of the earth on its axis, *before an illuminated sun*, and this did not happen until the fourth period.

2. The word day, in accordance with the practice of all languages, is used even in this short history, in three senses: for light as distinct from darkness, for the light and darkness of a single terrestrial revolution, or a natural day; and, finally, for time at large.

3. In the latter case then the account itself uses the word day in the sense in which geology would choose to adopt it, that is, for time or a period of time.

This latter fact appears to be overlooked or neglected by most of those who have criticised the views of geologists, as Professor Jameson justly remarks, "with an unnecessary severity;" but we have a right to hold them to this case, which is exactly in point, being presented precisely where we should wish to find it, and we shall therefore regard it as proving our point; for in the recapitulatory view of the creation in the beginning of the second chapter of Genesis, allusion is made to the whole work, in the expression "*in the day* that the Lord God made the heavens and the earth."

4. If the canons of criticism require that one sense of the word day should be adopted and preserved throughout the whole account, *how* are we to understand this verse? "These are the gen-

erations of the heavens and the earth when they were created, *in the day* that the Lord God made the heavens and the earth." Which of the three senses shall we adopt? If the most common, then the whole work was performed not in six days, but in one day—of twenty four hours in the popular sense; but according to the geological views the work was done in a sufficient time, be it more or less. The canons of criticism were made by man, and may therefore be erroneous, or at least they may be erroneously applied; the world was made by God, and if the history in question were dictated by him, it cannot be inconsistent with the facts. Why then should we not prefer that sense of the word used in the history itself, which is in harmony with the structure of the globe! It is said indeed by some critics, that the account in the second chapter of Genesis is a different one from that in the first; but with this opinion the geologist, as such, can have no concern; and since he finds both accounts in a connected history, he receives them as one.

It is agreed on all hands, that the Hebrew word here used for day, although frequently used for time, usually signified a period of twenty four hours; and the addition of morning and evening is supposed to render it certain that, in the present case, this is the real sense and the only one that is admissible, especially as this view is said to be supported by the peculiar genius of the Hebrew language.

But, in all languages, whenever the subject requires, it is usual to preserve this allusion to morning and evening, even when the word day is used for time; thus, when for instance we speak of the life of a man *as his day*, in harmony with the rhetorical figure we speak also of the morning and the evening of life.

In all ages, countries, and languages, as already remarked, this sense of the word day is fully sanctioned, and it is frequently so used in the Scriptures.* Indeed, it might not be too much to suppose that the arrangement by which the sun was to measure time was not completed until the evening of the 4th day, and then our difficulties will be confined to one day, namely, the 5th. The first three days, obviously, could not have had the present measure of time applied to them, and their morning and evening must there-

* See the instances already cited on page 558.

fore have been figurative; an arbitrary division of time, accommodated to the advancing creation, and the work of arranging the crust of the planet was so far finished by the evening of the 5th day, as to fit it for the reception of terrestrial quadrupeds, which first appeared on the 6th day, and finally, man was created, as would appear, at the conclusion of the same day; of course, the great geological revolutions, *beneath the bed of the ancient ocean*, must have been so far finished on the 3d day that the continents began to emerge, and thus dry land began to be provided not only for vegetables, but for terrestrial quadrupeds and for man, neither of which could, before this period, have existed on the earth. All this was done before the present measure of time was applied; we do not say before there was light, for elementary light was "the first born of the creation," nor even before the sun shone, but before he was set "to rule over the day and over the night."

In the usual mode of understanding the account, all the immense deposits of coal, and of early vegetable remains and marine animals, with their vast strata and mountains, the grand mausoleums in which they lie entombed, must have been made within seventy two hours, for there was no dry land until the 3d day, and consequently no terrestrial vegetables; they appeared on that day, aquatic animals on the 5th, and land animals, with man, on the 6th; but the latter could not, as observed above, have appeared until the continents had emerged.

According to the popular understanding, the transition and secondary mountains with their coal beds, plants, and animals were therefore formed, by physical laws, in two or three natural days, which is incredible, because it is impossible.

We cannot conceive, therefore, that even the limitation of morning and evening is decisive against the extension which we would claim, and we are left at liberty to interpret the word day in harmony with the facts of geology.

It is granted that Moses himself probably understood the word day according to the popular signification, and as regards the history in question, this sense is certainly the most obvious one to every mind not informed as to the structure of the globe; even those who are learned on other subjects, but ignorant of geology, always adopt, in this case, the literal and obvious meaning. This however proves nothing; for the truths of astronomy are in ex-

actly the same situation. Until the modern astronomy arose, no one, whether learned or unlearned, entertained a doubt that the earth is an extended plain; that it stands on a firm foundation, even on pillars, and that around it as a center, the sun and starry heavens and the azure canopy, as a solid palpable firmament, revolve, while the waters of the heavens descend through its windows.*

Such is still the impression of barbarous nations, while few even of the common people of enlightened countries would now fall into so gross an error; and no one in this age fears that he shall, like Galileo, be thrown into prison for declining (on this subject) to understand the Scriptures in their literal sense.†

It is objected as already stated, that as the sabbath is a common day, and that as it is mentioned in the fourth commandment, and in other parts of the Scriptures, in connection with the other six days, they ought to be limited to the same *time*.

We cannot see that this consequence follows. The sabbath is a moral enactment; all that precedes was physical, relating merely to the creation and arrangement of matter, and to irrational organized beings; the sabbath could have no relation to rocks and waters, vegetables and animals: it was ordained for man, as a rational being, to bring back his thoughts to his Creator by a day which naturally recalls the great act of creation; and in mercy as a day of rest from labor both for him and for the animal races that

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* For an admirable view of the inconsistencies of those who would adopt the light of science as regards the firmament, the rains, and the starry host, and celestial space, and deny the same liberty to geology as regards extension of time, see Am. Journ. of Science and Arts, Vol. xxx, p. 114, Sig. K.

† When the present system of astronomy was introduced, it met with the most violent opposition, and the following is the "Judgment pronounced at Rome, in 1622, only two hundred and seventeen years ago, on the Philosophy of Galileo, and on the Philosopher himself, by the seven Cardinal Inquisitors." "To affirm that the sun is in the center, absolutely immoveable, and without locomotion, is an *absurd* proposition, *false* in sound philosophy, and moreover *heretical*, because it is expressly contrary to *Holy Scripture*. To say that the earth is not placed in the middle of the world, nor immoveable, is also a proposition *absurd and false* in sound philosophy; and considered theologically, is at least erroneous with respect to faith." "Whereupon Galileo so refuted, was compelled on his knees to abjure, curse, and detest the *absurdities, errors and heresies*, which the sagacity of the Cardinal Reviewers and Inquisitors had discovered in his writings."—*Penn's Compar. Estimate, &c., 2d Ed. Vol. I, p. 37.*

were to labor for him: it was a new dispensation, and although the same word is applied both to this period and to those that preceded, it does not appear to follow that the original periods were then, as they are now, of the same length. As the first three days that preceded the establishment of the relation between the sun and the earth could have no measure of time in common with our present experience, it appears to be no unwarrantable liberty to suppose that they may have been of any length which the subject matter may require, although those three days were also verbally limited by morning and evening, and that at a period of the creation when there could have been no morning and evening, in the sense in which those words are now used. It is very remarkable that the seventh day is not limited at all, either by morning or evening, like the other days, and although it must have been actually limited as to its beginning, it does not appear that as a day of rest and cessation from the work of creation it is even yet ended, after nearly 6000 years; therefore as regards the Supreme Being it has been already of that length, and we know not when it will end.

The revolution of the earth on its axis in the presence of an illuminated sun being necessary to constitute morning and evening, it must also revolve with the same degree of rapidity as now, in order to constitute such a natural day, with its morning and evening, as we at present enjoy. But as already suggested, the sun not being ordained to rule the day until the fourth of those periods, it is not certain that even after this epoch, those early revolutions of the earth on its axis were as rapid as now; for these might cease altogether, or be greatly increased in rapidity, without affecting the planetary relations of the earth with the sun and with the other members of the system. The historian, as he must employ some term for his divisions of time, naturally adopted one that he found in familiar use, but it appears, both from the subject matter to which it is applied, and from the use made of it in this very history, that the word day is not in the present case necessarily restricted to its most common acceptation.

Is it asked whether Moses had any mental reservation, a double sense for the word day—one for the common people and one for men of science; we answer that as it appears from his brief, sim-

ple and merely optical statement, that he had no astronomical knowledge beyond what was current among the Egyptians of that day, so it is almost certain that he had no geological knowledge beyond the order of time and events in the creation which his history exhibits. It is very probable that fossil and entombed organized remains and fragmentary rocks, and indeed most of the facts which geology has developed, were unknown to him, that he had observed little on this subject beyond the annual sedimentary deposits of the Nile, and that, as he told a story for mankind at large, he told it in the same spirit and with the same understanding with which it is commonly received. This however decides nothing more than in the case of all the sacred writers who relate astronomical events, or who allude to astronomical appearances in the vulgar sense, which is in direct contradiction to the actual state of facts in astronomy; whereas geology contradicts nothing contained in the Scripture account of the creation; on the contrary, it confirms the order of time and events, and requires only that the time should be sufficiently extended to render it physically possible that the events should happen, without calling in the aid of miracles in a case where natural successions are sufficient to account for all the facts.

It may be worthy of remark, that supposing that there are inhabitants at the poles of the earth, to them a day of light is six months long, and a night of darkness is six months long, and the day, made up of night and day, covers a year, and it is a day too, *limited by morning and evening.*

So *at* the polar circles there is once in every year a continued vision of the sun for 24 hours, and once in the year a continued night of 24 hours; while every where within the polar circles, the days and the nights respectively are for six months, more than 24 hours long, extending even, as we advance towards the poles, through the time of many of our days and nights. How are these people to understand the week of the creation, if limited to the popular view entertained in countries between the polar circles?

In Mercury	the day is	24½	hours long.
In Venus	"	over 23	" "
In Mars	"	24h. 40m.	"
In Jupiter	"	nearly 6 hours	"

In Saturn the day is over 10 hours long.
In our Moon " a lunar month.

Thus it appears that the actual days of the planets differ considerably, and that of the earth* differs remarkably at and within the polar circles, as those in lower latitudes differ very much from each other.

The result of all our inquiries, then, is this.

We find that the geological formations are in accordance with the Mosaic account of the creation; but more time is required for the necessary events of the creation than is consistent with the common understanding of the days. The history therefore is true, but it must be understood so as to be consistent with itself and with the facts.

It is agreed on all hands, that there may be time enough for the central rocks before the first day; we have already given our reason why we cannot throw back the creation of organized beings into the indefinite period that precedes the first day; vegetables and animals are introduced in connection with the days and not before, and there is no reason to suppose that there has been a double creation or merely a new arrangement of fragments and ruins; therefore if the days be regarded as periods of time, so as to allow room for the events assigned to them, relating to organic beings, and to the masses in which they are entombed, all difficulty is removed.

On the contrary, if they are restricted to the usual popular sense, it is not physically possible that the events should have happened within the time assigned; but they did happen, and as there was no call for miracles in cases where natural operations alone were sufficient, there can be no doubt that sufficient time was allowed.

It is scarcely necessary to remark, that when the order and arrangement of creation was fully finished, and man appeared on the earth, the measures of time were, without doubt, finally established the same as now, and therefore we are not at liberty, as

* An eminent biblical critic and Hebraist, now in Europe, once remarked to me, when speaking of the word day as used in the first chapter of Genesis, that the use of the word in the three first days was *mere costume*, (manner,) and if so in those cases, why, added he, may they not be so considered in all?

there is clearly no occasion, to regard them in any other than the usually accepted sense.

It is no valid objection to the supposition of more time than is commonly allotted to the week of the creation, that there were no human beings to be spectators of the work. Even upon the popular view they were excluded, because the human race did not appear until the very last act of the creation. Had they, however, been co-existent, they would scarcely have understood what was passing, as most of the geological facts were veiled by the ocean. But there were not wanting spectators; God, and angelic beings, far superior in intelligence and dignity to man, looked on, while in the beautiful and highly figurative language of the Scriptures—"the morning stars sang together, and all the sons of God shouted for joy."*

Before closing these remarks, we will respectfully submit a few suggestions for the consideration of two very different descriptions of persons, namely, *those who deny, and those who defend, the truth of the Mosaic history.*

To the former class, so far as they are geologists, we will say, that, in relation to geology, any attempt to disprove the truth or genuineness of the Pentateuch, and of Genesis in particular, is wholly superfluous, and quite aside from any question that can, in this age, be at issue between geologists. No geologist, at the present day, erects any system upon the basis of Scripture history, or any other history. Still, historical coincidences with natural phenomena have always been regarded as interesting, because they are mutually adjuvant and confirmatory. The letter of Pliny, describing the death of his uncle, would have been true, although Herculaneum and Pompeii had never been discovered; and it would have been true that those towns were overwhelmed by a volcanic eruption, although the letter of Pliny had never been written; or being written, if it had been false as to the main fact of the death of the elder Pliny, or of their having been an eruption at the time assigned in that writing. But an authentic letter exists describing the event, and as it coincides with the facts revealed by the discovery of the buried cities, conviction

* In this summary we have found it necessary to repeat some remarks in a new connexion.

flashes upon every mind, and the unexpected and beautiful coincidence, like many of those that add strength to the evidence in support of the sacred volume, affords one of those firm points of reliance upon which our confidence reposes with delight. Now if there is not sufficient proof in the appearance of the earth, that it was for a long time covered by water, and that the waters deposited, in the then forming strata and mountains, those organic bodies, of aquatic origin, which we find entombed in them, then no geologist of the present day would, in that character, on the authority of the first chapter of Genesis alone, assume the fact of terrene submersion, as the basis of his reasoning and as the foundation of a geological system.

In the same manner, if he find on the face of the earth no proofs of diluvial devastation; if there be nothing to evince, that mighty rushing waters have torn up and transported to a distance the movable materials of the surface; then, as a geologist, he will never assume the Mosaic account of the deluge as the basis of a system of diluvial agency, any more than he will build similar conclusions upon the poetry, fables, and mythology, or even upon the history, of the ancients. But if he discover proofs, and those too, generally admitted by well instructed geologists, of both the stupendous events named above, or of a succession and diversity of such events, sufficient, on the whole, to mark the entire earth by the effects appropriate to each; if then he finds a history of high antiquity, and generally revered wherever known, describing such a state of things as the condition of the planet reveals, what rule of science or of philosophy can debar him from bringing the two into comparison, for mutual illustration, as is always done in the case of other antiquities. Why should any one object to his applying the terms of the history, as he understands them, and then measuring the phenomena by them, and them by the phenomena? If they agree, surely, it is reasonable that conviction should receive augmented strength in his mind. Should they, however, disagree, the phenomena, if correctly observed and correctly reported, will still be true, and the credit of the history will, of course, be impaired. Should, moreover, the genuineness or authenticity of the history be disproved, from other sources than the phenomena, the latter will still remain in all the obstinacy of

immutable fact, which history may indeed illustrate, but cannot, on the contrary, disprove. If the history, on the other hand, be confirmed by the natural phenomena, it has then received the greatest confirmation possible, and may well exult in so powerful an ally.

Should it, in the case of the Pentateuch, be proved even, that there was never any such person as Moses, or that the books that pass under his name were written by others, or that they are compilations of ancient and vague traditions, or even of reputed or real fables, this would not, in the least, affect the system of geological truth that has been erected by an ample course of investigation and induction. But, as long as the Mosaic history is admitted to be both *genuine* and *true*, any geologist who receives the history in that character, may, with strict historical and philosophical propriety, illustrate the history by geology, and compare geology with the history.

This he will do merely on the ground of historical and geological coincidence, and without drawing for the support of his scientific views upon any portion of his moral feeling, towards a work which, as an individual, he may revere as a communication from his Maker, for purposes far more important than the establishment of physical truth.

To personal imputations on his motives, his science or his skill, or on those of eminent philosophers with whom he has the honor to think and to act, while he leaves the case, with the grand inquest of the learned, the candid and the wise, he will reply in no other manner than by expressing the hope that powerful and cultivated, but *unbelieving* minds, minds confiding implicitly in physical, but *sceptical* with respect to moral truth, may be influenced to see the harmony *of all truth*, whether historical, moral or physical, and to remember that man is, after all his acquirements in knowledge, a being, so darkly wise, although rudely great, that he is constantly in danger of error, error against which he should the more studiously guard when the physical subjects which may be the objects of his study have also a high moral relation. While, therefore, in geology, as well as in other sciences, we fully approve, and follow the course of rigid induction—(the only safe and truly philosophical process of investigation, and

solid basis of physical truth,) we hold it to be entirely proper in a scientific view, to avail ourselves of every apposite historical fact, from whatever credible source it may be derived. Indeed, no geologist hesitates to cite history, travels, personal narrative, and even poetry and tradition, in confirmation or illustration of earthquakes, floods, or volcanic eruptions; of the rising or sinking of islands; of alluvial increase or destruction; of ruptures of the barriers of lakes; of irruptions of the sea—or whatever other fact may be the subject of his investigation. Why then should the Scripture history form the only exception among historical authorities?

Having made these suggestions to those geologists who are not believers in divine revelation, we will now address a few remarks to believers who are not geologists.

The subject before us is not one which can be advantageously discussed with the people at large. A wide range of facts, a familiarity with physical science, and an extensive course of induction, are necessary to the satisfactory exhibition of geological truths, and especially to establish their connexion and harmony with the Mosaic history. It is a subject exclusively for the learned, or at least for the studious and the reflecting; but as regards their own mental furniture, it can no longer be neglected with safety, by those whose province it is to illustrate and defend the sacred writings. The crude, vague, unskilful, and unlearned manner, in which it has been too often treated, when treated at all, by those who are, to a great extent, ignorant of the structure of the globe, or who have never studied it with any efficient attention, can communicate only pain to those friends of the Bible, who are perfectly satisfied, after full examination, that the relation of geology to sacred history, is now as little understood by many theologians, and biblical critics, as astronomy was in the time of Galileo.

Non tali auxilio, non defensoribus istis, tempus eget!

There is but one remedy; theologians must study geology, or if they will not, or from peculiar circumstances, cannot do it, they must be satisfied to receive its demonstrated truths from those who have learned them in the most effectual way, not only in the cabinet, but abroad on the face of nature, and in her deep recesses.

They will then be convinced that geology is not an enemy, but an ally of revealed religion; that the subject is not to be mastered by mere verbal criticism; that faithful study must be applied to facts, as well as to words, and that there is, at most, only an apparent incongruity, an incongruity which vanishes before investigation.

The mode in which the subject is now treated, or rather neglected or spurned by many theologians and critics, (not by all, for there are honorable exceptions,) is not safe, as regards its bearing on the minds of youth. If they go forth into the world in the stiffness of the letter, and without the knowledge or proper application of the facts, it is impossible that they should sustain themselves against those who, with great knowledge, and no reverence, may too powerfully assail what they cannot defend. In the pulpit, however, geology can be but very imperfectly explained, even by him who understands it; for it is impossible that he should there, intelligibly and adequately exhibit his proofs; they rest on a multitude of facts unknown to a common audience; and they are too far dependent on specimens, sections and other graphical illustrations, to be understood in such circumstances, especially by those who have enjoyed no mental preparation in kindred sciences, and in courses of inductive reasoning. Since the subject has no other connexion with our faith as Christians, than so far as it affects the credibility of the early Scripture history, it is therefore wise, as to the literal sense of the days, not to disturb the early and habitual impressions of the common people, or even of the enlightened, who are ignorant of geology. Any discussion before such audiences, and in such circumstances, will be misunderstood, or not understood at all, and will only prejudice the reputation of the speaker without benefiting the hearer.

This, however, does not excuse the theologian from being fully prepared to meet the subject in other places, and in situations where it will be forced upon his attention. *It is a part of the panoply of truth, in which he should be fully clad,* although he may rarely draw his bow, and perhaps never let fly an arrow from his appropriate watchtower.

As the case now stands, with respect to most theologians in this country, the geological arguments in support of the Mosaic

history, although powerful and convincing, are unknown and neglected, or they are denied, slighted and avoided; and of course they can be, and they actually are, by some few geologists, turned, with too much success, against the sacred records; it remains with the defenders of those records to say, whether the purloined weapons shall be returned to the armory whence they were stolen, and from which they may be again drawn forth for efficient use in support of the cause of truth.

Theologians who were trained before geology was understood, and before it was possible to acquire, in our seminaries, an adequate knowledge of its elementary truths, are not included in these remarks, and we are happy to observe the increasing attention which is paid to the subject by some students in the sacred science.

After a long course of careful study on this subject, the study of the earth in mines and mountains, as well as in books and cabinets, we feel it our duty to declare, that this noble science merits not the neglect with which it is frequently treated, nor the reproaches and hostility with which it is too often assailed. This mode of treatment will not destroy the facts, or for a moment retard the progress of truth. Were the thunders of the Vatican* now levelled at geology, as they were two centuries ago at astronomy and some of its early cultivators, it would no more avail than it then did. The march of truth is onward, and onward it will go. Denunciation, neglect or sneers, will not arrest its course, nor can ignorance or misrepresentation long hold it in dishonor. The Christian world must and will admit its established truths, and these truths teachers must learn, or their pupils will leave them in the darkness which some appear to covet.

Kind communications and instructions will remove the doubts and fears of those who are anxious lest old foundations of faith

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* The Vatican stands acquitted on the present occasion, for it is a curious fact, both in morals and science, that the lectures of the Rev. Dr. Nicholas Wiseman, of the Catholic church, Principal of the English College, and Professor of the University of Rome, recently delivered in Rome itself, under the very eye if not the listening ear of the Pontiff, contain a view of the connexion of geology with the Scripture history, so *truly catholic*, and in the main, *so just in science*, that it may well gratify a Christian geologist, and reprove many Protestant divines.

should be disturbed, and they will perceive that the building does not totter to its fall, but that new buttresses and props have fixed it, more firmly than ever, on an immovable basis of physical as well as moral demonstration.

These suggestions have been made with the sincere and earnest hope of doing good, especially to those who greatly neglect a subject of high interest, which it much concerns them to know.* But it will be no new case, should a mediator between hostile armies fail to conciliate either party, and only provoke the artillery of both; nor would it create either surprise or displeasure, should the writer of these remarks be regarded as an intruder on consecrated ground. This ground, however, he considers as common to all the friends of truth, and among geologists there are not a few who regard the Scriptures with quite as high an interest as physical science, and who are anxious to prove, that where others discover only discord, there is a principle of harmony, which a skilful hand may draw forth, in tones delightful to all who have an ear to perceive and relish "the universal harmonies of nature."

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* It is perhaps not improper to mention, that an eminent Hebrician and biblical scholar, who had been trained up in the common opinions, which he had cherished for many years, and had never doubted their correctness, was entirely convinced on hearing a course of geological lectures, fully illustrated by specimens and drawings. With great candor he himself came out the next season, 1835, in a public course of lectures on the subject of the creation, and in the same room, (that of the Franklin Hall at New Haven,) avowing his conviction of the truth of our geological views, fully vindicated the extension of time required by geology; even in the days themselves, as well as in the antecedent period.

See also a very able and candid discussion of this subject in the comment of Prof. Bush, late of the New York University, on the book of Genesis. We hazard nothing in predicting many conversions on this controverted subject, and ultimately perfect harmony between Christian geologists and Christian teachers.

The view taken by Prof. Bush corresponds, substantially, with that sustained by Dr. Murdock, namely, that the long periods of the creation called days, may have been made up of many shorter days, each having its morning and evening. We are in no degree anxious as to the mode in which critics may furnish an explanation consistent with the requisite extension of time, provided the time be associated with the successive creations and fossilization of the organic beings which are truly medals of the ancient world.